The Journal of ENGINEERING EDUCATION

March, 1960 *Table of Contents* Vol. 50, No. 7

Do You Know 519

Education for Survival — A. K. Sibley and W. H. McNeice 523

Purdue University, Annual Meeting Host for 1960 533

Young Engineering Teachers Summer Institute 536

What Caused College Students to Study Engineering — L. G. Smith 537

Experimental Educational Television — J. L. Martinez 541

The Effect of the National Defense Education Act on Engineering Education — K. L. Holderman 544

Where Do We Get Our Ethics? — S. W. Chapman 548

A Proposal for the Unification of Student Engineering Societies — Frank Krieth and Preston Parr 551

Physics and Engineering Education: Complementary or Supplementary? — R. J. Seeger 556

Statistical Thermodynamics — J. F. Lee 560

Sponsored Research—Good or Bad? — R. A. Morgen 565

Faculty Compensation for Sponsored Research: Good or Bad? — W. A. Koehler 569

Chow Line or Cafeteria — G. J. Christensen 572

Part-Time Graduate Study in the New York Metropolitan Area — A. B. Giordano 574

Part-Time Graduate Electrical Engineering Programs in the San Francisco Bay Area — J. M. Pettit 582

The New York University Graduate Center at Bell Laboratories — S. S. Shamis 587

Candid Comments 555

Teaching Positions Available 591

Civil Engineering Division Bulletin 594

What's Going On in ASEE — W. Leighton Collins 595

Notes

Co-op Graduate Program 532
New Phoenix Director 535
New Frontiers for Freshmen 540
NSF Program Director 540
NSF Fellowships 568
Classroom Design Study 571
Information Projects 586
Cooper Union 581

Copyright © 1960, The American Society for Engineering Education

Members of the Editorial Committee for the Journal

Paul T. Bryant	Editor of the Journal and Chairman
Clarence E. Bennett	University of Maine
Renato Contini	New York University
Albert H. Cooper	University of Connecticut
Benjamin J. Dasher	Georgia Institute of Technology
Raymond O. Darling	General Motors Corporation
Arthur W. Davis	Iowa State College
Harold A. Foecke	Notre Dame University
Amy V. Hall	University of Washington (Prof. Emeritus)
Lee Harrisberger	North Carolina State College
John L. Imhoff	University of Arkansas
James J. Kauzlarich	Worcester Polytechnic Institute
W. W. Kriegel	149 Dallam Rd., Newark, Del.
Arthur Lesser, Jr.	Stevens Institute of Technology
George A. Marston	University of Massachusetts
Thomas L. Martin, Jr.	University of Massachusetts
Jeanne I. Miller	Technical Education News, McGraw-Hill Book Company
James M. Moore	Clarkson College of Technology
William E. Restemeyer	University of Cincinnati
Harry T. Rice	Esso Standard Oil Company
Thomas H. Rockwell	Ohio State University
G. Reed Shaw	Rensselaer Polytechnic Institute
Wayne L. Shick	University of Illinois
Frank R. Smith	Air Force Institute of Technology
Benjamin J. Ulrich, Jr.	West Virginia University
Howard L. Wakeland	University of Illinois

1960 ANNUAL MEETING, PURDUE, JUNE 20–24

Do You Know . . . .

► . . . . That in making arrangements for the Annual Meeting you will want to plan on arriving on Sunday? This year the meeting really gets into full swing on Monday! In the morning the TI Division presents its final report on the National Survey of Technical Institute Education and in the afternoon is the formal opening session featuring President Teare's address and a discussion of engineering education philosophy by Dr. Frederick L. Hovde, a member of ASEE and also President of Purdue University. Incidentally, Purdue agreed to this only after yielding to outside pressure.

► . . . . That ASEE has another offspring? First it was the Japanese Society for Engineering Education and now there is the Brazilian Association of Professors of Engineering! Twenty-one of the 24 engineering schools in Brazil attended the founding meeting at the National School of Engineering of the University of Brazil in Rio de Janeiro, where a constitution was adopted and officers elected. The first president is J. O. Monteiro de Camargo of the Polytechnic School, University of São Paulo.

► . . . . That there are 880 subscribers to the Journal of Engineering Graphics? This long-time publication of the Engineering Graphics Division is issued three times per year and costs $1.25 per year. Subscriptions should be sent to Wayne L. Shick, 210 Transportation Building, University of Illinois.

► . . . . That there are 666 subscribers to the Engineering Economist? About three-fourths are from industry and one-quarter in education. The subscription rate for the four copies per year is $4.00 in the United States and Canada. Subscriptions should be sent to Laura Corridon, Business Manager, Stevens Institute of Technology.

► . . . . That at the recent CDEF conference it became apparent that engineering educators should do more reading in areas such as psychology and education in order to get a better understanding of the teacher-learning process? Those few engineering teachers who have been digging into this problem find that engineering education has frequently been studied by people in other areas, but the engineering teacher does not know of the results because they are published in the journals in the authors' area of specialization. Three reports of this nature (each is not over ¼ inch thick) are, "The Liberal Arts as Viewed by Faculty Members in Professional Schools," "Liberal Education in the Professions," and "Are Liberal Arts Colleges Becoming Professional Schools?" Copies are available at no cost from the Institute of Higher Education, Columbia University.

► . . . . That plans are in the making for the study of mechanical engineering laboratory instruction? Programs were developing at several places, and at the ASME annual meeting in Atlantic City interested parties got together to formulate a plan which probably will result in a joint ASME–ASEE study. NSF support will be sought for a small closed conference followed by an open conference during the summer of 1960. It is contemplated that a continued action program will be necessary for several years thereafter.

► . . . . That AIEE through its Research Committee is endeavoring to stimulate, encourage, and promote research in colleges and universities? It is circulating a memorandum, "An Invitation to Research." The committee has no funds to sponsor programs, but will provide guidance and aid in obtaining suitable sponsorship.

► . . . . That a conference on "Mechanical Properties of Engineering Ceramics" is being held at North Carolina State on March 9–11? Significant new developments relating to the fundamen-

tal parameters governing mechanical properties will be discussed. The Office of Ordnance Research is a co-sponsor.

► . . . . That the proceedings of the 4th Midwest Symposium on Circuit Theory are available for $7.00 per copy? About sixty electrical engineers from throughout the U. S. and Canada attended the two-day symposium at Marquette University. Place orders with R. J. Kipp, Director of Engineering Institutes, Marquette University, 1515 West Wisconsin Avenue, Milwaukee 3, Wisconsin.

► . . . . That engineers received 5 of the 75 Senior Post-doctoral Fellowships granted by NSF for the fiscal year 1960? Two of the five have university affiliation. Five schools in four foreign countries are to be attended. There were 259 applicants.

► . . . . That there were 85 engineers among the 285 Science Faculty Fellowships awarded in the sciences by NSF for the fiscal year 1960? The recipients came from 63 schools, all but 6 of which are members of ASEE. There are 3 recipients from each of 6 schools and 2 recipients from each of 10. Thirty-eight different schools are to be attended, 5 of them abroad. Eleven recipients selected Purdue, 6 are going to Wisconsin, 5 to Illinois, 4 each to Michigan, Michigan State, Stanford, and the University of California at Berkeley, and 3 to Columbia, MIT, and Washington University at St. Louis. In 10 cases the recipient is to attend his own school. The total number of applicants was 762. Compared to the 85 awards in engineering, there were 63 in mathematics, 34 in chemistry, and 32 in physics. It really looks as though engineering teachers are beginning to take advantage of some of the opportunities offered them.

► . . . . That a recent poll of the Department of Defense revealed that there are approximately 24,000 officers within four years of retirement who are interested in teaching. Approximately 3600 have an M.S. degree and approximately 1100 others have the Ph.D. degree. A large percentage will be under fifty years of age upon retirement. Two-hundred and fifty institutions indicated that they already employ 620 retired military personnel, 197 as administrators and 423 as teachers. Almost 400 institutions reported 878 unfilled positions for the academic year 1959–60 that might be filled by qualified military personnel, and 135 were in engineering. The study was made by the American Council on Education.

► . . . . That about 780,000 scientists and engineers were employed by American business firms in January 1959? About 35% of the total were engaged in engineering and scientific research and development. It is estimated that the number of scientists and engineers in industry represents about two-thirds of the total number of scientists and engineers employed in the nation. Engineering employment increased from about 605,000 in January 1958 to 630,000 in January 1959. These are some of the data from the forthcoming report of the Bureau of Labor Statistics conducted for the National Science Foundation.

► . . . . That the national manpower needs for technical information personnel are being studied by the Modern Language Association of America? The number and importance of these specialists is becoming critical in areas of chemical, electronic, nuclear, and space industries. The specific needs of industry, government, and research organizations will be ascertained. The suggested training recommended by such potential employers, the professional titles, salaries, specific duties, and the immediate and future employment picture will be determined in order that plans may be established for the development of four or five-year college programs definitely identifying and preparing professionals for this work. Foreign language skill, good writing style knowledge of the basic sciences, skill in the techniques of information research, and a background in the humanities are the requirements for a specialist in the field. Additional information can be obtained from the Modern

Language Association of America, FLP Technical Information Project, 50 Broad Street, New York 4, New York.

► . . . . That the medical profession is worrying about the steady drop in the number and quality of applicants for medical schools? Since 1950 the number has declined about one-third, and the result is that the caliber of students has decreased. Evidence is that in 1950–51, 40% of entering students had an average grade of A; in 1957–58 only 18%. During the same period withdrawals after one year have increased from 5% to 7.8%.

► . . . . That the national program to study methods of improving the teaching of physics in college is being undertaken by the American Association of Physics Teachers? A steering committee with Dr. F. W. Sears, Chairman of the Department of Physics at Dartmouth College, as Chairman is administering the initial NSF grant of $69,000. A series of meetings involving prominent physicists is planned, along with the sponsorship of a book on lecture demonstrations to supplement and bring up to date the volume now issued by the AAPT.

► . . . . That NSF has announced a permissible increase in indirect cost rate on basic research projects from 15% to 20%? The new policy, taking effect January 1, 1960, allows for rising costs of administration and the adverse effect of such increases upon the ability of institutions to carry on research work. In no event, however, may such indirect costs exceed the last "audited" or "negotiated" rate approved for the institution by a federal agency for purposes of government sponsored research and development.

► . . . . That ASEE and ECPD joined with EJC in developing the U. S. participation in the Pan-American Congress on Engineering Education to be held in Buenos Aires, Argentina on September 12 to 16, 1960? The five topics selected for discussion by UPADI are Faculty Recruitment, Engineering Curricula, Admissions, Registration and Recognition, and Graduate Studies. The speakers selected are W. L. Everitt, F. C. Lindvall, R. A. Morgen, J. H. Sams, and B. R. Teare, Jr., respectively. The direct representatives of the three Societies charged with the responsibility for reporting to U. S. organizations on the activities of the Congress are, N. A. Hall, for ECPD, H. K. Justice, for EJC, and W. Leighton Collins, for ASEE. Participation in the Congress is to be financed by a grant from the National Science Foundation to EJC, the U. S. representative to UPADI.

► . . . . That the demand for engineering graduates will increase to such an extent that by 1966 there will be 15 graduates recruited for every 10 hired in 1959? This is one of the conclusions of EJC's Engineering Manpower Commission and stated in its report, "Demand for Engineers–1959." There were no widespread acute numerical shortages of engineers because of the large number of graduates available for immediate employment. The demand by industry and government for engineers has increased over that of a year ago when the temporary recession produced a close supply-demand balance. Starting salaries were at an all-time high, averaging $510 per month for B.S. graduates, $600 for M.S., and $825 for Ph.D.'s. The report further states that engineering turnover in 1958 averaged 9.5% as compared to 11% for 1957 and an expected 8.6% for 1959. Resignations account for 55% of the losses, death and retirement 9%, and military leave 6.5%. The future industrial demand, or recruiting, in terms of gross additions was 13.4% in 1959; by 1966 this is expected to be 20.6%.

► . . . . That industrial employers expect to hire in 1959 one additional technician to every 10 now employed? Inplant training of additional technicians also corresponds to one for every 10 now employed. This compares to a gross addition in 1958 of 7.3%. These are some of the findings of EJC's Engineering Manpower Commission and reported in "Demand for Engineers–1959." Copies

of the fifteen page report can be obtained directly from EJC.

► . . . . That the newsletter distributed on a limited basis by EJC as the "Engineer" is to be replaced by a newspaper which will be distributed directly to about 300,000 engineers? It will report on activities of EJC and other joint society organizations as well as national affairs of interest to the profession. It is proposed that there will be four to six issues per year starting in 1960. There will be no subscription rate. Since this is to be every engineer's paper, all are urged to comment and offer suggestions in establishing it as an effective voice of all engineers. Myron Weiss is Editor and Publisher, and communications should be directed to him at Engineers Joint Council, 29 West 39th Street, New York 18, New York.

► . . . . That EJC has received an NSF grant for a visiting foreign scientist program in engineering? The objective is to broaden the scientific perspective of faculties and graduate students in engineering through interchange of scientific knowledge and research concepts. Appropriate engineering socities in five areas of specialization are to assume the responsibility for the selection of the visitors and the planning of the itinerary.

► . . . . That "Your Approach to Professionalism" by N. W. Dougherty is a new publication of ECPD? The manuscript developed from a series of lectures to engineering seniors that "N. W." gave at the University of Tennessee when he was Dean of the College of Engineering. Copies of the 48-page, 8.5 by 11-inch, publication are available from ECPD for $1.00 each; there is a discount of 10% on 10–100 copies and 25% on 100 or more.

► . . . . That ASTM has established a doctoral fellowship program? It is for the final year of full-time graduate work on a doctor's degree relating to the "knowledge of materials" and consists of $5000 for the recipient and $1500 for the school. The first award, to begin in September of 1960, has been made to the University of Illinois.

► . . . . That JETS continues to grow rapidly? Founded at Michigan State in 1950, there now are over 660 chapters in 41 states and Puerto Rico. The "Junior Engineering Technical Society" functions through chapters in high and junior high schools to enhance pre-engineering and science programs. The national headquarters, Box 589, East Lansing, provides program material, etc. at no cost. Current programs are financed by gifts from industry and an NSF grant. Is your high school interested?

► . . . . That within a few weeks you will be receiving the preliminary program for the Annual Meeting? The program is challenging and top-flight, probably the best ever. Purdue says the meeting will be the best ever! So, make your plans now to be at Purdue for June 20–24!

► . . . . That "1016" engineering seniors were surveyed in the article by J. L. Seminara instead of "101" as stated in the February "Do You Know?" Apologies are extended to all for the error. The "1016" makes a difference in the reliability of the precentages, doesn't it?

► . . . . That it takes three to five men a full day to name the Society committees? The incoming President always meets with the retiring President, the Secretary, and, if possible, appropriate Vice Presidents in order to make the best selections. But long before the group meets suggestions for people to serve on committees are solicited from chairmen of committees and Divisions, as well as from all members of the General Council. The hundreds of names submitted and the suggestors are then tabulated by committee for consideration by the officers. This year Section Chairmen also will be solicited for suggestions to equalize the Division-Section influence.

W. Leighton Collins
Secretary

Education for Survival

ALDEN K. SIBLEY

Brigadier General, U. S. Army

AND

WILLIAM H. McNEICE

Each of us has heard, actually or figuratively, the explosions of "A" bombs and "H" bombs. I suggest that the most significant explosions may not be those of "A" bombs and "H" bombs reverberating around the world. The most important explosions may be those unheard explosions in the minds of men: thought explosions we call ideas. Ideas are today our most important, although sometimes our least respected, commodity. We in the United States have before us some of the hardest and most demanding thinking we have ever had to do. This thinking, if it is to be wise and conducive to our survival in the nuclear age, must be born of a common understanding among educators, scientists, engineers, soldiers and statesmen—an understanding which we have not always enjoyed. It must be a courageous understanding that dares to come to grips with the thermonuclear bomb and look beyond to man's greatest and most challenging opportunity to master the forces of nature for the benefit and not the destruction of mankind.

The aphorism "knowledge is power" perhaps should read today "knowledge is survival." It is only through knowledge and understanding of the forces of nature and the motives of men that we may chart our course by the stars and not by the lights of each passing ship.

It is important that we see the central role which ideas have played in the development of human society. If our century has sometimes forgotten the importance of ideas, has honored the gadget before the theory, production of nuclear energy may be a large enough event to correct the error somewhat, because the production of nuclear energy was impossible until thinking men advanced the frontiers of man's understanding. From this thought, these ideas, have come the incredible energy sources that have changed the tactics of war and have caused the rethinking of innumerable previous thoughts and ideas. Ideas are in a sense the nuclear bombs of culture and progress.

The development of nuclear energy is a dramatic instance of what has repeatedly occurred in the history of mankind. For our purposes it can teach an important lesson. Among other things, it can teach us vividly the basic importance of what is sometimes thought to be "useless" knowledge.

Useless Ideas

The story behind the atomic bomb and nuclear energy is an exciting tale of "useless" idea piled upon "useless" idea. The story is worth a brief re-telling because it embodies the three things I would emphasize above all for the age which nuclear energy has ushered in. These are (1) the overwhelming importance of pure science in man's struggle to master nature; (2) the deep and genuine need for mutual understanding and cooperation between scientists, engineers, educators, statesmen and the American public; and (3) the need for imaginative thinking, for the free examination of ideas and concepts in the fields of education, industry, politics, and statesmanship which a new scientific concept creates.

Presented at the April, 1959, meeting of the Southeastern Section of ASEE.

Let us look for a moment at the pure research which led to costruction of the first atomic bomb. Among these contributions were those of Henri Becquerel, a Frenchman, who first discovered the phenomenon of radioactivity; Niels Bohr, a Dane, and the Bohr model of the atom; Louis de Broglie, a Frenchman, the founder of modern wave mechanics; Werner Heissenberg, a German, with his elaborate matrix mechanics; Albert Einstein, a German, and the mass-energy relationship; Max Planck, a German, and the quantum theory; Pierre and Marie Curie in France and their researches in radium; Lord Rutherford, in England, and the identification of alpha, beta and gamma rays; Robert Millikan, an American, and his classic oil-drop experiment with which he measured the charge on a single electron; F. W. Aston, an Englishman, and the mass spectrograph; C. T. R. Wilson, an Englishman, who developed the Wilson Cloud Chamber for observing the tracks of high speed particles; P. M. S. Blackett, an Englishman, who photographed the first artificial transmutation of an element; Sir James Chadwick, an Englishman, who proved the existence of the neutron; and finally Lise Meitner and Otto Hahn of Germany, who succeeded in splitting an atom of uranium, thus producing the first nuclear fission.

From this point on, the making of a nuclear bomb was largely a technological problem, a now familiar story. The world first heard the word "fission" in August 1945 when Mr. Churchill released the story of the Hiroshima atomic bomb. With the release of the Smythe Report the story was told. But that does not bring the story quite up to date. A fission bomb can be made only so big and no bigger. The limit is set by its "critical mass," and an atomic bomb cannot be made bigger than this or it will blow itself up while being made. The trick is to make a ball of uranium isotopes just slightly smaller than the critical mass—then by squeezing it under the implosion of TNT, like squeezing a sponge-rubber ball, its density is increased and surface escape area reduced enough to trap the neutrons and make it explode. Hence it is impossible to build a fission bomb more than several times as powerful as the Hiroshima weapon. However, pure scientists had not been idle.

In 1938 an astrophysicist, Hans Bethe, at Cornell University, showed how energy radiated by the sun comes from the burning of hydrogen atoms into helium, a process he called the "carbon cycle." Two very light atoms can fuse together into a heavier one with loss of weight, according to Einstein's mass-energy relation, just as one extremely heavy atom can split into two lighter ones with loss of weight. But the two hydrogen atoms have to be subjected to the tremendous heat of the central regions of the sun before they can be made to fuse together. And in "Operation Greenhouse" on Eniwetok in 1952, Norris Bradbury, Edward Teller and others made enough heat with an ordinary atomic fission explosion to burn a container of hydrogen isotopes into helium for the first time on earth. Two years later, the March 1, 1954, shot at Bikini was the first man-made thermonuclear weapon ever exploded on earth. The literally world-shattering significance of this thermonuclear bomb, whose hydrogen atoms won't fuse at normal temperatures, is the absence of critical mass. Moreover, there are enough of the proper hydrogen isotopes in sea water to make a pound of heavy water sell for about twenty-eight dollars.

The impact of these developments upon our concept of war as a means of dealing with international problems constitutes a subject in itself. And we can well search the writing of Clausewitz, Mahan, Douhet and MacKinder, for an age without precedent has real need for military guidance. Wars of the past have been fought for land, for wealth, for ideals, for blondes and brunettes for that matter. But wars of the future will be fought for none of these things primarily. Assuredly, if there are to be wars of the future, they will be fought for something man holds priceless, something for which he is willing to give his life and risk the lives of others. That something may well be the control of the world energy sources.

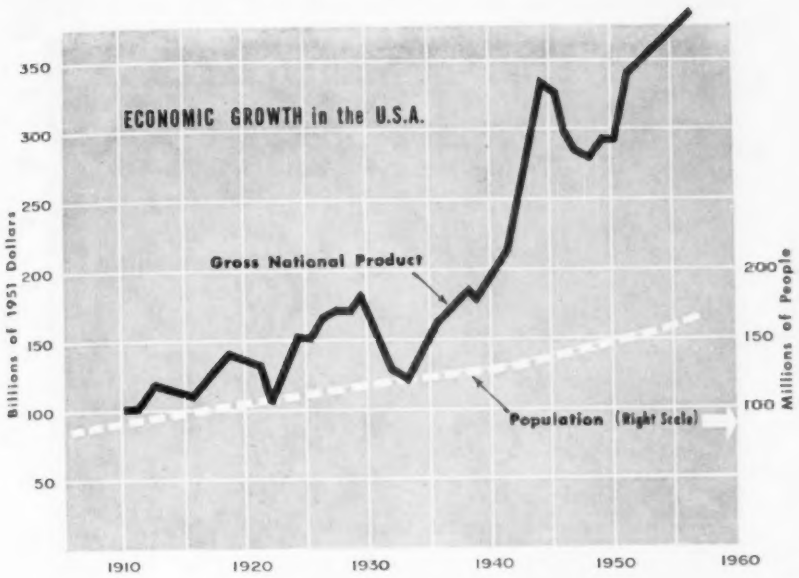

ECONOMIC GROWTH in the U.S.A.
Billions of 1951 Dollars
350
300
250
200
150
100
50
Gross National Product
Population (Right Scale)
Millions of People
200
150
100
1910
1920
1930
1940
1950
1960

FIG. 1.

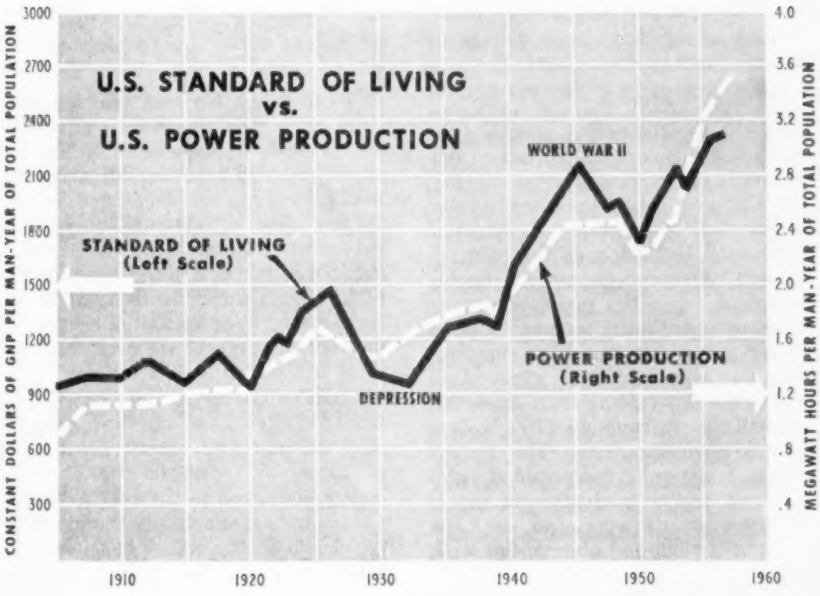

U.S. STANDARD OF LIVING
vs.
U.S. POWER PRODUCTION
CONSTANT DOLLARS OF GNP PER MAN-YEAR OF TOTAL POPULATION
3000
2700
2400
2100
1800
1500
1200
900
600
300
STANDARD OF LIVING
(Left Scale)
WORLD WAR II
DEPRESSION
POWER PRODUCTION
(Right Scale)
MEGAWATT HOURS PER MAN-YEAR OF TOTAL POPULATION
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
.8
.4
1910
1920
1930
1940
1950
1960

FIG. 2.

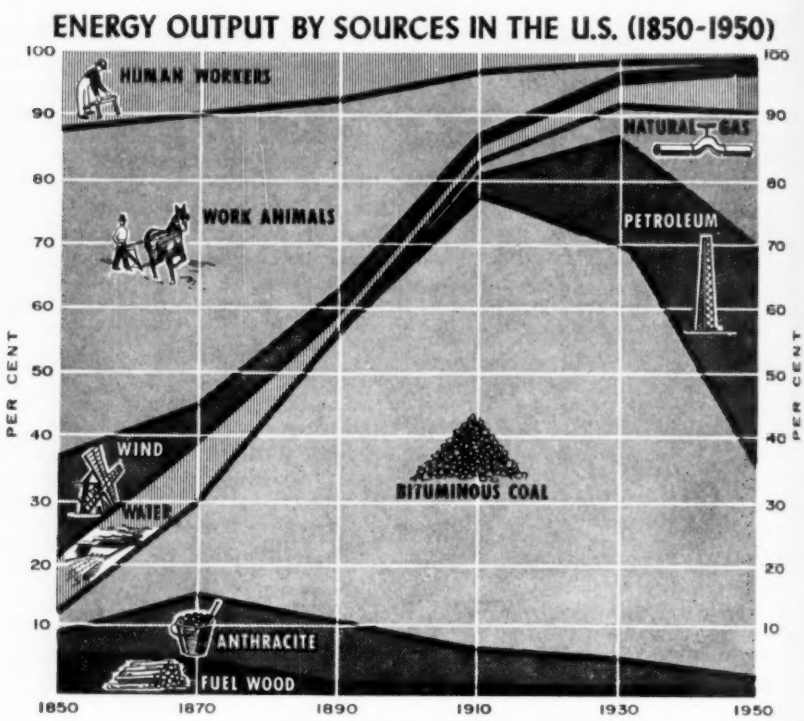


FIG. 3.

World Energy Sources

In 1910, the 100 million people of the United States produced 100 billion dollars worth of goods and services (Fig. 1).[1] The gross national product has shot up out of all proportion to population growth until, in 1957, it hit the $400 billion mark. Extended, the curve is roughly exponential while the population curve shows only an arithmetic increase. Plotted as GNP per capita, the curve approximates the growth of our standard of living. On what foundation does this exponentially expanding $400 billion standard of living rest? The answer emerges if we quite independently plot per capita power production in megawatt hours per man per year, over the same time period, and observe the startling correlation between the two curves (Fig. 2). The significance is evident: our priceless heritage of social and economic progress is irrevocably tied to the use of energy in ever-increasing amounts. In ten, fifty or one-hundred years, to maintain the progress we have come to think of as inherent in the American way of life, we shall evidently need to consume a staggering amount of energy. To find out how much, we must first know what kinds of energy we use.

Conventional sources of energy in the United States have changed gradually over the past 100 years. The top line of Figure 3 represents 100% of the energy consumed in the year indicated.[2] Contributions from various energy sources are shown by the curves beginning with wood energy at the bottom; anthracite

[1] Source of data used in Figures 1 and 2; Vitro Corporation of America, New York City, New York.

[2] 1953 Annual Report of the Twentieth Century Fund.

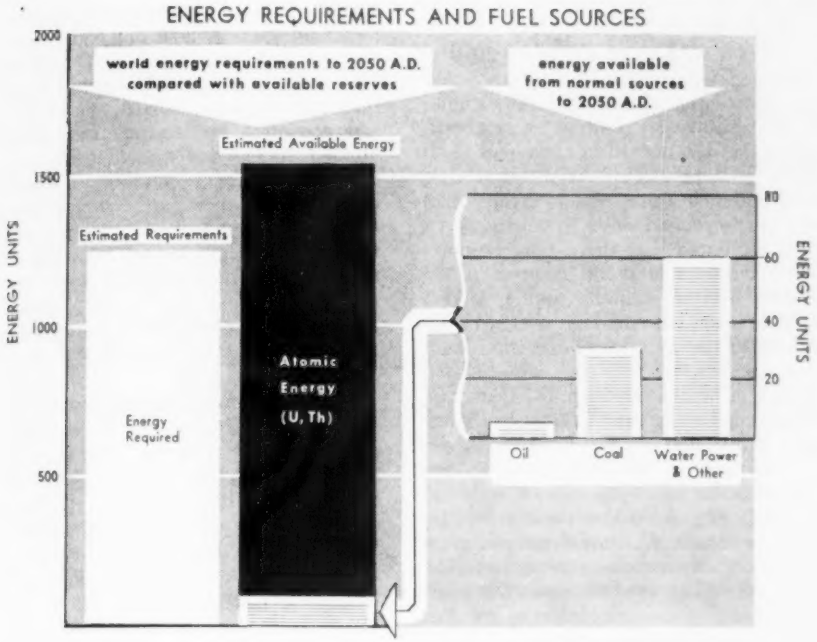


FIG. 4.

coal; bituminous coal, which peaked in 1910; oil, which was negligible before 1890; gas, which came in even later; hydropower, which decreased to a minimum early in this century and is now expanding; windpower, horsepower and manpower, all three of which now contribute negligible amounts. It is interesting that in 20 years the 70% to 30% ratio of coal to oil and gas in 1930 had almost exactly reversed itself by 1950. But the age of plenty in fossil fuels is drawing to a close.

How much energy will be needed in the next 100 years, and where will it come from? If one realized that today's Soviety strategic plans, like stock market trends, are educated guesses of tomorrow's conditions, Figure 4 can be a frightening picture. On the left are shown world energy requirements for the next 100 years.[3] At an exaggerated scale on the right are shown the total amounts of energy available in the world from all known conventional sources. When compared to requirements and reduced to this same scale, all normal sources of energy will yield about one-tenth of the world's requirements over the next 100 years. This does not mean that all the world's conventional energy resources will be exhausted by 1970, because the requirements' curve is roughly exponential. It does mean, however, that at the average rate of predicted energy consumption in the next 100 years, less than a 10-year supply is available from known conventional sources in the world. If we are prodigal in burning up our fossil fuels for energy, there will be little left for the vital chemical processes on which we have come so largely to depend.

Palmer Putnam, in his comprehensive report to the Atomic Energy Commission on energy resources and requirements, generally corroborates this evaluation of the world energy problem although in-

[3] Compiled by A. C. Montieth, Westinghouse Electric Corp.

dicating a somewhat greater reserve of nuclear fuels.[4]

Using a burn-up of 487 Q by 2050 as estimated by Putnam, the future world energy situation appears generally similar to that previously outlined.[5] He estimates that the net world reserve of fossil fuels (coal, oil-gas, oil shale, tar sands), recoverable at a unit cost no greater than two times present costs, is about 27 Q. It is estimated that there exist economically recoverable world reserves of 25 million tons of uranium and 1 million tons of thorium, yielding over 575 Q. Added to the 27 Q available from fossil fuel reserves, we will thus have a total reserve of 602 Q, of which 487 Q may be burned up by the year A.D. 2050. Thus, peak production in fossil fuels may occur in the not too distant future. In the United States new low-cost sources should be ready to pick up much of the load by 1975 or sooner, which will mean a great expansion of nuclear power facilities. That we will successfully meet this challenge before serious depletion of low cost conventional fuels appears doubtful.

A few pioneering and federally subsidized industries are building nuclear power plants in this country and abroad. Coal-hungry England, with 12 mill thermal power, inaugurated in the fall of 1956 the world's first full-scale atomic power plant at Calder Hall, Cumberland. The Calder Hall Station, which produces about 75,000 kilowatts (enough to supply a city of 200,000) is the first reactor of a United Kingdom nuclear power program of five million kilowatts by 1965. The United States, on the other hand, burning up fossil fuel resources at far cheaper rates, lags in development of nuclear power. When nuclear fission power is seriously developed, however, the world's known deposits of uranium and thorium will be adequate for the next 100 years with a little to spare. But what then? With the continued social and economic progress of the United States irrevocably tied to the consumption of energy in ever-increasing amounts, the ensuing decades of this and the next century will certainly be characterized by a struggle for control of world energy resources, whether the struggle be political, economic, military or a combination of all three. Since economically recoverable world energy sources are limited, efforts toward their further development and control are increasingly subject to the law of diminishing returns. The nation which applies its brainpower most effectively may expect to reap rewards in the form of new energy sources far in excess of the fossil fuels stored in the earth's crust.

All such sources as may someday be discovered lie hidden not in the mines of the earth, but in the minds of men. Perhaps perfection of the controlled thermonuclear fusion reaction will be the answer. If so, a cheap and almost limitless supply of energy exists—theoretically enough to run the world for the next 10,000 years.[6] But the intense heats of the fission explosion, which succeeded in fusing the light isotopes of hydrogen, lasted only a fraction of a micro-second. The problem of sustaining heats and pressures comparable to those in the central regions of the sun seems almost insurmountable on earth. Thus, perfection of a sustained thermonuclear reaction for production of usable energy remains one of today's greatest challenges to science. However, in spite of the recognized urgency of this problem and today's crash programs to solve it, the finest and most optimistic of the world's scientific minds do not anticipate an early solution. Today we have the H-bomb but no H-furnace. Whether we shall achieve a controlled thermonuclear reaction in the next 100 years we do not know for sure. The difficulties of maintaining and containing these enormous temperatures and pressures for more than a few microseconds of a thermonucluear explosion present some of the most formidable problems in physics and engineering with which the minds of men have ever had to cope. Yet if the problem is not solved before

[4] Palmer C. Putnam, *Energy in the Future*, D. Van Nostrand Company, Inc., New York, 1953, Chaps. V, VI, VII, VIII.

[5] 1.0 $Q = 1.0 \times 10^{18}$ Btu, equivalent to 38 billion tons of bituminous coal.

[6] Energy in 1 pound of heavy water is equivalent to that of 2,500 tons of coal.

the depletion of our remaining sources of fission energy, the prospects will be bleak for generations as near to us as our grandchildren. Even if the problem is solved in time, the wide expanse of the oceans of the earth contains only enough thermonuclear energy sources to last about 10,000 years. What shall man use for energy after that? Perhaps he must find a way to convert the energy of the sun's rays directly to his needs.

A few of the possible methods of harnessing the sun's rays as a continuing source of energy, none of which now appear capable of competing with the cost of conventional or even nuclear fuels, but which all deserve further intensive research by physicists, chemists, and even geneticists, are such methods as solar collectors and batteries, controlled biological synthesis to exploit the energy-producing mechanism of photosynthesis in single-celled algae,[7] thermocouples, photo-voltaic cells, oxidation-reduction systems, photochemical decomposition of water, storage of heat in crystal lattices, storage of light in phosphors, and non-biological photosynthesis.

In addition to direct exploitation of the energy of the sun's rays, we cannot overlook a source available from our natural sputnik, the moon. With a mass about 1/81 of that of the earth, revolving at a mean distance of only ten times the earth's circumference, the moon causes tidal movements of our oceans, a continuing source of energy that man has thus far done little to harness. In an era when the need for energy has never been so great, nor the exhaustion of conventional sources of fuel so imminent, engineers of both the United States and France, realizing that man must not fail to examine all possible sources of low-cost energy, have embarked on the world's first two tidal power projects of any significant magnitude. On the LaRance River in France, Electricité de France has now under construction a tidal plant, employing a new type of reversible turbo-generator, which is estimated to produce about 0.8 billion kilowatt-hours of energy annually. In my office of the New England Division of the U. S. Army Corps of Engineers we have recently completed and submitted to the International Joint Commission of the United States and Canada a three-year study of an international United States-Canadian tidal power plant in the Maine-New Brunswick area to harness the tides in the Bay of Fundy between Passamaquoddy and Cobscook Bays. We estimate that this project, using a conventional river hydroelectric plant as an auxiliary, would generate annually over 3 billion kilowatt-hours of electricity.[8]

Chances for Survival

These are the problems of the near and distant future, but their very urgency is our challenge to think, our chance for survival in the nuclear age. Although we cannot hope to solve them here today, we can, I believe, draw some conclusions. Energy will shortly become the most priceless possession of man, a possession on which his way of life, even his life itself depends, and therefore one for which he will fight. The real war of today and tomorrow is the war of men's minds. What are our chances of survival? How are we doing in the race to train American minds to win the thinking war—the war of pure science, of fundamental research?

A brief review of the state of science and technology in America may point to the answer. By science I mean what is usually called fundamental research: the free, uncharted probing into the unknown merely for the satisfaction of curiosity and the accumulation of knowledge, the

[7] A pilot plant for production of several pounds a day of Chlorella (one of some 17,500 algae of which some 10,000 deserve investigation) was operational in 1952, although producing energy costing 150 times as much as the energy in coal.

[8] Other areas where tidal energy may prove economically feasible are sites in the upper Bay of Fundy, the Severn on the West Coast of England, the Bay of L'aber Vrach on the north coast of Brittany, Mt. St. Michel in northeast France near St. Malo, in Argentina the Gulf of San José and the mouth of the Deseado River south of the Gulf of San Jorge, and in the U.S.S.R., the Kola Peninsula, the Mezen Gulf, and the Sea of Okhotsk.

development of basic scientific innovations from which technology springs. By technology I mean applied science, developmental or goal-oriented research, engineering, the systematic use of primary scientific knowledge for a purpose.

It has long been accepted that the United States has made a far greater contribution to the development of technology than any other nation in history. No other nation approaches us. Our closest competitor, the Soviet Union, has approximated only one-third of our technological advances as measured by relative productive capacity today. It is no mere whim of the European that has led him so often to characterize America as a nation of gadgeteers.

In contrast, our contributions to pure science have been far less impressive. Americans tend to honor structure over design, the gadget more than the theory. Yet in the age of slow neutrons, radioisotopes, and nuclear fission, the nation which excels in pure science may well control the world. There are reasons for the American penchant for gadgeteering, of course, many of them fairly obvious. We have had at our disposal a vast geographic expanse containing an enormous wealth of natural resources. After three hundred years, great areas of our country still remain sparsely populated. We have always had room to move, resources to draw on. We have always been faced with the challenge to build—the challenge of engineering. We have been the fortunate inheritors of the pragmatic spirit which brought the Pilgrims to our country and sent the pioneers across the western plains, relying on their common sense and ingenuity to cut a living from the raw and rugged continent they had chosen. Ingenuity born of necessity has led us inevitably to become a nation of gadgeteers. Like the Romans, we love to build things. We are the greatest skyscraper, road and bridge builders that the world has ever known. Today we continue this tradition, we build and produce empirically.

Although increasing quantities of our federal budget—over 5 billion dollars a year—are poured into research and development, this is research and development of a very special kind. It is largely developmental research: applied science, technology, and engineering. Only about 10% of it is pure research. We research the hell out of everything, but we contemplate very little.

In the past this has been in many ways our strength. But it can be very strongly argued that we are moving into a different age—an age when respect for ideas, when respect for the basic contemplation of nature and society for the simple sake of seeking truth and satisfying curiosity may be much more necessary than we have previously realized.

Warren Weaver, Vice President of the Rockefeller Foundation and Director of its Division of Natural Sciences and Agriculture, in an article published in *Scientific American* (September 1958),[9] has shown that in the past 25 years financial support of research and development in this country has multiplied 25 to 30 times while expenditure for basic research has multiplied only 10 times and has declined from 20% to less than 10% of the national expenditure. Employment of scientists in America, which has multiplied 5 times in the past 25 years, has shown the greatest increase in industry, where most scientists are engaged in applied research, while the number of scientists in universities today account only for some 20% of the total employed. And of these university scientists, less than half are engaged in basic research—a situation which should be the cause of grave concern. To further aggravate the problems of the universities, we see a situation where it has become necessary for professors to supplement their incomes by summer work, during a period when they should be devoting their time to reading, thinking, and their own research.

Time and Balance

A fact that we must recognize is that it takes time for a student to become a scientist. And further, we must not hope to compress into a single generation the broad range of work which in the end

[9] "The Encouragement of Science," pp. 170–178.

must be carried on over a number of generations to come. We certainly cannot expect a "crash" program in scientific education at all levels to bear fruit with the first graduating class. We must be careful also not to sacrifice other essential subjects of liberal education on the altar of science. It would be well in this respect to remember that throughout history great advances in fundamental knowledge in science have gone hand in hand with glorious periods in art and literature.

A beginning, however, must be made. President Eisenhower, in a speech at Oklahoma City in November, 1957, said: "One thing that money cannot buy is time. Frequently time is a more valuable coin than is money. It takes time for a tree to grow, for an idea to become an accomplishment, for a student to become a scientist. Time is a big factor in two longer term problems, strengthening our scientific education and our basic research. . . . Young people now in college must be equipped to live in the age of intercontinental ballistic missiles. However, what will then be needed is not just engineers and scientists but people who will keep their heads, and, in every field, leaders who can meet intricate human problems with wisdom and courage. In short, we shall need not only Einsteins but Washingtons and Emersons." This poses a formidable challenge to American educators today both on the secondary and university levels. With education more important to long-term national security than ever before, the efforts and aims of educators and students alike must change fundamentally.

Perhaps the Russians are wrong in such a concentration of national effort in science. If they are wrong, they will have an overabundance of scientists. If we are wrong in developing too few scientists and high quality engineers, it may cost us our survival as a nation. It is hard to avoid the conclusion that the Federal government, industry, private foundations and each of us as individuals must come squarely to grips with this problem.

I believe the Federal government has in the past two years shown a remarkable record of progress in facing the challenge of achieving high quality secondary, undergraduate, and graduate education and in broadening the base of pure scientific research in the United States. A few highlights of this record are establishment of the Science Advisory Committee and appointment of Dr. James R. Killian as Special Assistant to the President; expansion of the National Science Foundation program; creation of the Research Project Agency and the office of Director of Research and Engineering in the Department of Defense; re-establishment of the Science Advisor in the State Department; and establishment of the broad program in support of education under the National Defense Education Act of 1958.

The Universities' Responsibility

Thus the proposals made by President Eisenhower in 1957 were translated into action. But we should not for a moment think that anything more than a beginning has been made. The Federal government can do no more than prime the pump; the basic responsibility for educating America's youth lies with you. No matter what the volume and source of support, we must look to our universities for the imagination and wisdom that will secure the maximum benefit to science.

It is here in the universities where individuals of high intelligence must seek the climate that favors the creative process. And the challenge facing the university today in fulfilling their foremost obligation—education of the student—is a great one. It is here that we must bridge the serious gap between the level of achievement in the average American secondary school on the one hand and the intellectual level of our top graduate professional schools on the other, and this gap must be bridged in a mere four years of undergraduate study. Thus a nationwide effort must be made to provide in our secondary schools that vigorous training expected of every candidate for admission to a first class European or Russian technical institute or university. Then, perhaps, our universities may one day see an entering freshman who will

not expect education by spoon feeding, who will realize that he is his own teacher, and will thereby allow the university to fulfill its true function: that of inspiring him, of counseling and directing his studies, of providing him library and laboratory, and affording him the great benefits of intimate association with first class minds.

The universities, however, cannot do the job alone, nor should we think for a moment that with the advent of Federal aid the support of industry, the efforts of private foundations and individuals are no longer needed. Such support is needed as never before. Not only must we support our educational institutions directly, but we must somehow supply adequate incentives to young scientists to provide for them a rewarding future in the laboratories of fundamental research. Unfortunately, in the United States economic success is seldom a laboratory by-product. We support projects but not men. Tragically in our country the road to economic success and the presidencies of corporations leads not through the laboratory. A mathematician, to be economically successful by American standards, must forget mathematics, learn to sell soap, buy a house near the country club and drive two cars. Othesrwise, he is a square, a queer sort of non-conformist whom "normal" Americans may secretly suspect.

I certainly would not recommend adoption of Soviet methods, but Americans must realize that the time for educational dilletantism—for poor and underpaid teachers and the tendency of a student to just "get by" in order to play football—has long passed. We must learn to think and think hard if we are to escape the fate of the Roman Empire. We are the richest nation in the world. We have the highest standard of living in the world. We cannot allow ourselves to go soft. We must have the courage to pay the annual premiums on our national insurance policy with adequate military stature and scientific and technological strength. Just as a rich man must lock his door at night not to tempt the housebreaker, so we must be prepared to protect our riches or we shall surely lose them to the international gangster who will take them if he dares. To carry out such a challenging program requires more than national fortitude. Survival in the nuclear age requires national brains.

CO-OP GRADUATE STUDY PROGRAM

Support for the University of Cincinnati's new co-operative program of graduate study and basic research in engineering and the physical sciences through a $200,000 five-year grant was announced by the Ford Foundation, New York City. The university's program is believed to be the first of its kind.

With a background of 53 years' experience in co-operative engineering education at the undergraduate level, the university last fall inaugurated its graduate co-operative program with the support of some of the largest industries in the Cincinnati area.

The Ford Foundation grant will aid in financing the program during its development phase.

The university's new program not only will provide a doctoral education for the increasing numbers of engineer-scientists required by industry but will give trainees the advantage of actual experience in basic research in industrial laboratories not available in the traditional, non-co-operative form of graduate study. The university this fall accepted eight students in this program who are classified as research fellows. Some are working toward master's degrees, others toward the doctorate.

The doctoral degrees now offered include majors in physics, chemical engineering, and metallurgical engineering. By 1961–62 the program will also include doctorates in aeronautical, civil, electrical, and mechanical engineering. The university now offers master of science degrees in these fields.

Purdue University
Annual Meeting Host for 1960

Purdue University is a co-educational state university named in honor of John Purdue, who contributed both money and 150 acres of land toward the founding of the University in 1869. Purdue is one of the nation-wide chain of sixty-nine land-grant colleges and universities owing their origin to the Morrill Act signed by President Lincoln on July 2, 1862.

According to the provisions of this Act, the Federal Government offered to turn public lands over to any state, the proceeds of which were to be used to establish and maintain a college to teach the agricultural and mechanical arts. As a consequence of this provision, Purdue, from the time of its founding, has specialized particularly in the areas of engineering and agriculture. Throughout its history, however, the University has abided by the further principle of the Morrill Act that land-grant colleges, in addition to concentrating on agriculture and engineering, must not fail to include in their curricula "other scientific and classical studies—including military tactics."

Today, therefore, in addition to the Schools of Engineering and Agriculture, the University is composed of Schools of Science, Education and Humanities, Home Economics, Industrial Management, Veterinary Science and Medicine, and Pharmacy, as well as several other departments not included in the foregoing schools.

The first regular classes at Purdue began on September 16, 1874. Six instructors were employed to teach the 64-member student body of the first year. Richard Owen, son of cooperative economist Robert Owen, had served as first president of Purdue since 1872, guiding the destinies of the University during its earliest building stage, but he retired shortly before actual classes began. Frederick L. Hovde, head of the United States rocket development during World War II, became Purdue's seventh president in 1946.

Purdue's undergraduate and graduate enrollment today totals more than 14,000 students. About 5,000 other students attend Purdue University Centers in four other Indiana cities—Hammond, Indianapolis, Fort Wayne, and Michigan City. These students are taught, and research is conducted, by 1,400 full-time faculty members in some 70 buildings.

Within the past seven years the University has more than doubled the valuation of its physical plant, which today is valued in excess of 100 million dollars. The University has been co-educational since the second year of its existence. Today more than 2,200 women students attend Purdue, mostly in the School of Home Economics and the School of Science, Education and Humanities.

The University owns 16 principal farms, totaling more than 8,000 acres, on which experimental work and research in agriculture are carried on.

Buildings of Interest

Among the buildings on the 550 acre West Lafayette campus which invite special attention are the following:

The Purdue Memorial Union, headquarters for social activities for students, faculty, alumni, and visitors. Among its facilities are 257 rooms for resident guests, 14 bowling lanes, cafeterias, a dining room and coffee shop, browsing and music rooms, twin ballrooms, a sweet shop, lounges, barber shop, alumni headquarters, and offices and printing press for the student daily newspaper. Headquarters for the 1960 ASEE convention will be in the Memorial Union and the adjacent Memorial Center.

Opened in 1958, the Memorial Center contains the general library of the University. This library, together with the

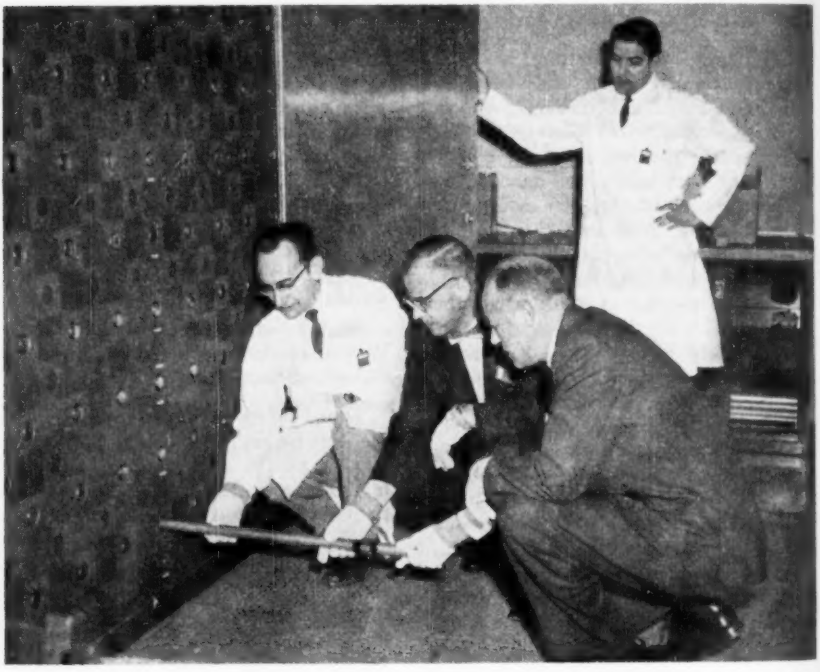
various departmental libraries, contains almost one-half million bound volumes. In addition, the Memorial Center contains two theaters designed for convocations, meetings, plays and the like, and an experimental theater. It also houses the offices of the Division of Adult Education, a number of exhibit and demonstration rooms, lounges, a billiard room, a ballroom, and offices for student organizations.

The Edward C. Elliott Hall of Music is the largest theater in the world. The Hall of Music accommodates more than 6,000 spectators, and contains broadcasting studios of WBAA, the voice of Purdue, and offices and practice rooms for the Purdue musical organizations and bands. Both the Hall of Music and the Memorial Center are air-conditioned.

The new Co-educational Recreational Gymnasium, opened in 1957, features three swimming pools, two outdoor and one indoor, and facilities for a great variety of sports including basketball, rollerskating, badminton, archery, handball, squash, shuffleboard, riflery, gymnastics, volleyball, etc. This building, like the Purdue Memorial Union, the Hall of Music, the Memorial Center, and the residence halls, is entirely self-financed. No state funds have been used in their construction.

The Ross-Ade Stadium seats more than 53,000 for Big Ten football games. Purdue meets its basketball opponents in the Fieldhouse, which accommodates some 9,600 spectators.

The Life Science Building is the largest single structure on the Purdue University campus. It houses the departments of Biological Sciences, Animal



President Frederick L. Hovde and other officials of Purdue University insert a tube containing natural uranium into a graphite pile to start up a sub-critical nuclear assembly. Kneeling left to right are Prof. V. E. Bergdolt, associate director of the new Nuclear Engineering Laboratories; Dr. George A. Hawkins, dean of engineering; and President Hovde. In the background is B. G. Dunavant, radiological control officer of the University.

Purdue oval with John Purdue's grave in foreground.

Science, Botany and Plant Pathology, and Agronomy. This building contains some of the most up-to-date and completely equipped laboratories to be found anywhere in the nation for teaching and research into the life sciences.

Discussion of the Engineering Buildings and other facilities which will be of particular interest to those attending the ASEE Convention in 1960 is being deferred until the third and final article in this series.

NEW PHOENIX DIRECTOR

Henry J. Gomberg, assistant director of the Michigan Memorial Phoenix Project since Dec. 1, 1951, has been appointed director of the project at The University of Michigan.

The appointment to the top post in the University's extensive research program in the peaceful uses of atomic energy was approved by the U-M Regents after they had granted the request of Vice-President Ralph A. Sawyer that he be replaced as Phoenix Project director.

Vice-President Sawyer, director of the project since June 1951, was appointed to the new position of vice-president for research on September 25, and has continued since then as dean of the School of Graduate Studies and Phoenix director.

Young Engineering Teachers Summer Institute on Effective Teaching

A Planned Program

A two-week program on engineering teaching to be held this summer will have the following purposes: (1) training in the fundamental principles and use of effective teaching methods, (2) orientation of young teachers to their profession as educators, (3) encouragement of research in methods for the improvement of learning. Topics to be discussed include:

1. Engineering Education: Objectives and Place in the Academic World
2. Principles of Learning
3. Optimizing Learning in Lecture, Recitation and Laboratory Classes
4. Teaching Aids
5. Tests and Examinations
6. Stimulating Creativity
7. Instructional Planning
8. Course and Curriculum Planning
9. Evaluation of Teaching
10. Research in Engineering Education
11. Developing Professional Attitudes

This institute is designed to give selected young teachers and institutional representatives an opportunity to study and practice successful teaching procedures. The impact of these methods on the learning process in engineering subjects will be the focal point of discussion.

To accomplish this task, leaders in the fields of psychology, education, and engineering are preparing special materials which will be presented during this summer institute.

Location: Pennsylvania State University.

Dates: August 29 to September 9, 1960.

Selection of Candidates: In this first year the participants will be limited to 25 young engineering teachers, under 36 years of age, who have had the equivalent 1 to 3 years of college-level teaching experience. The principal criteria for the selection of young teachers will be demonstrated ability and a desire to advance in the teaching profession.

In addition, 10 institutional representatives who are more experienced teachers will be included. These representatives will be selected with the understanding that they will endeavor later to conduct programs of similar content for other young teachers.

Remuneration: A stipend of $150 will be provided for each of the participants selected to attend the two-week institute. In addition, reimbursement will be made for campus living expenses and for transportation.

Application: Further information and an application form may be obtained from deans of engineering colleges. To guarantee consideration, all completed forms must be mailed by March 19. Applicants will be notified of their status by April 15.

This project is conducted by Pennsylvania State University with the co-operation of the American Society for Engineering Education and the Engineers' Council for Professional Development. Planning for the initial institute in 1960 and preparation of course materials are now in progress under a grant from the Ford Foundation.

For additional details write: Director, Young Engineering Teachers Summer Institute, Room 211A Sackett, University Park, Pennsylvania.

What Caused College Students to Study Engineering

What basic reasons are motivating our secondary school graduates to embark upon engineering as a career are of interest in several areas. In guidance work, an analysis of these motivating influences is of particular interest and value. Because of the need for a continued supply of engineers to sustain our modern economy, it is important that those high school students with the requisite aptitudes and the necessary abilities be encouraged to enroll in engineering courses in our colleges. To assist in the work of guidance, and to direct such activities into channels that will be most productive of results, it is essential to know how the secondary school student decided upon his choice of a career and what factors influenced him in making his decision.

To determine what these factors might be, 23 engineering colleges cooperated in surveying the engineering students, requesting them to complete the brief questionnaire to state what each student considered to be the principal influence which caused him to choose engineering. In all but one or two cases the survey was limited to members of the freshman class. To secure geographic distribution, requests were sent to several engineering schools in each of the eight regions into which the work of the Guidance Committee is divided. Table 1 shows the institutions which conducted surveys and from which replies were received. Because some schools contacted did not reply, there is some unbalance among regions. However, it is believed that the results, based upon replies of nearly 10,000 students, represent a well distributed national coverage and can be considered suitable for generalization and drawing of conclusions. A random selection of colleges, to which the questionnaire was sent, was made without regard to size, source of students, or state or privately financed.

The results of the survey, summarized in Table 2, are shown by regions and by total to indicate the average national trend. It is interesting to note that for the national total and the regions, all invariably show that the family is the greatest specific factor which guided the students into engineering. The national total for this factor is 25.7%, with the maximum for any region being 35.6% for Region VIII, and the minimum 18.3% for Region I. The availability of a scholarship seems to have but little influence upon the choice. An unexpected result is the relatively little influence that apparently is exerted by the high school counselor. The average shows that only 5.5% of the students gave credit to a school counselor as guiding them in their selection of engineering. Again this percentage was uniform among the regions, varying from 3.7 for Region IV to 8.6 for Region VII. In all cases it was low on the list.

It is of interest that 44.7% of those completing the questionnaire gave reasons other than the ones listed specifically. This appeared to be general, as the minimum percentage was 35.0 for Region VIII and the maximum was 56.6 for Region I. Among the reasons given under the heading of "Other" were personal interest, past experience—either military or job, feeling of aptitude, preference for mathematics and science and various other. Under Table 2 the principal ones are listed.

In some of the surveys, analyses by students enrolled in the various branches of engineering were included. These data were summarized in Table 3 and include the replies of 2,450 students. A

Results of a survey made by the Guidance Committee of Engineers' Council for Professional Development, 1959.

TABLE 1

COLLEGES FROM WHOM DATA WERE OBTAINED

Region I

Maine
University of Maine

Massachusetts
Mass. Institute of Technology

Vermont
University of Vermont

Region II

New Jersey
Newark College of Engineering
Stevens Institute of Technology

Region III

Maryland
Johns Hopkins University
University of Maryland

Pennsylvania
Carnegie Institute of Technology

Region IV

Alabama
University of Alabama

Florida
University of Florida

Georgia
Georgia Institute of Technology

North Carolina
North Carolina State College

Tennessee
Tennessee Polytechnic Institute

Virginia
Virginia Polytechnic Institute

Region V

Kentucky
University of Kentucky

Ohio
University of Cincinnati

Region VI

Nebraska
University of Nebraska

Wisconsin
Marquette University

Region VII

California
California State Polytechnic College

Montana
Montana State College

Nevada
University of Nevada

Region VIII

Colorado
Colorado State College

Texas
Agricultural and Mechanical College of Texas

comparison of the total for all branches in Table 3 with the national totals in Table 2 shows sufficient agreement to consider the figures by branches of engineering to be typical and representative. While there is some variation in the percentages for the various factors, the variations do not appear to be sufficiently great to indicate the drawing of any conclusions.

Conclusions

In applying these data to assist in charting the most effective course in our guidance work, the following should be considered:

1. Because of the predominating influence of the family, it is important that we present our story of the importance of and the opportunities in engineering to the parents. This can be accomplished in various ways, such as talks to PTA groups, talks by engineers to service clubs, publicity, including Engineers' Week activities.

2. The small influence apparently exerted by the high school counselor in guiding young people into engineering may be due to several reasons, such as: too few counselors who have to spread their efforts over many students; or lack of understanding on the part of coun-

TABLE 2

SUMMARY—MOTIVATING FACTORS CAUSING STUDENTS TO STUDY ENGINEERING

Motivating Influence	Region I		Region II		Region III		Region IV		Region V	
	No.	%	No.	%	No.	%	No.	%	No.	%
Teacher	110	8.1	77	12.9	132	14.5	505	12.2	116	13.1
Family	249	18.3	147	24.6	283	31.1	1106	26.6	240	27.0
Friend	142	10.4	48	8.0	68	7.5	409	9.9	103	11.6
School counselor	86	6.3	54	9.0	58	6.4	154	3.7	61	6.8
Availability of a scholarship	4	.3	9	1.5	30	3.3	65	1.6	53	5.9
Other*	770	56.6	263	44.0	339	37.2	1905	46.0	316	35.6
Totals	1361		598		910		4144		889	

Motivating Influence	Region VI		Region VII		Region VIII		Grand Total	
	No.	%	No.	%	No.	%	No.	%
Teacher	80	11.5	93	17.5	92	11.0	1205	12.1
Family	130	18.7	109	20.5	299	35.6	2563	25.7
Friend	48	7.0	76	14.3	103	12.4	997	10.0
School counselor	49	7.0	46	8.6	43	5.2	551	5.5
Availability of a scholarship	24	3.4	4	.8	7	.8	196	2.0
Other*	366	52.4	204	38.3	292	35.0	4455	44.7
Totals	697		532		836		9967	

* Breakdown of "Other":

Personal interest—own decision	Previous school courses
Military experience	Financial return
Job experience	Aptitude—hobbies
Job opportunity	Preference for math., science
Contacts with engineers in field	Ability
Reading	Other

TABLE 3

SUMMARY—ANALYSIS BY TYPES OF ENGINEERING OF MOTIVATING INFLUENCES TO STUDY ENGINEERING

Based upon 2450 students for which the information is available.

	Chemical Engineers		Civil Engineers		Electrical Engineers		Industrial Engineers		Mechanical Engineers		Aeronautical Engineers		Grand Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Teacher	68	20.3	41	12.7	91	12.4	11	12.0	94	12.8	30	12.8	335	13.7
Family	99	29.5	116	36.0	217	29.5	36	39.1	212	29.0	63	27.0	743	30.3
Friends	31	9.3	35	10.9	68	9.2	14	15.2	69	9.5	19	8.1	236	9.6
Counselor	22	6.6	18	5.6	25	3.4	5	5.4	27	3.7	26	11.1	123	5.0
Scholarship	28	8.3	9	2.8	13	1.8	3	3.3	18	2.6	5	2.1	76	3.1
Other	87	26.0	103	32.0	323	43.7	23	25.0	310	42.4	91	38.9	937	38.3
Totals	335		322		737		92		730		234		2450	

selors of the opportunities in engineering, what the engineer does, and what aptitudes and abilities are required in engineering. The results indicate the desirability of greater effort on our part to present the story of engineering to the counselors.

3. The fact that the teacher appears to be a more potent influence than the counselor indicates that we should bring the high school teachers into our field of activity. This applies particularly to the mathematics and science teachers.

4. It is significant that other factors than the family, friends, the teacher, the counselor, or the availability of a scholarship have a predominant influence in the choice of a profession. This indicates that the young people choosing engineering for their life work have independence of thought and analyze things for themselves. As related to guidance work, it means that we must reach the young people directly. This means speaking at school assemblies, being represented at career days, sponsoring engineering clubs in the secondary schools, encouraging science fairs, arranging inspection trips to industry for students, and bringing high school students into the activities of Engineers' Week.

6. The fact that the availability of a scholarship had but little effect upon students choosing engineering should not deter those engaged in engineering guidance work from assisting deserving and needy students aspiring to become engineers to secure scholarships. The availability of scholarships in other fields than engineering undoubtedly results in influencing the choice of a career. However, the availability of a scholarship to one who has decided that he wants to be an engineer but lacks the necessary funds may make his going to college possible.

L. G. Smith
Chairman,
Guidance Committee, ECPD

NSF PROGRAM DIRECTOR FOR ENGINEERING SCIENCES

Kenneth G. Picha has been appointed as Program Director for Engineering Sciences in the Mathematical, Physical, and Engineering Sciences Division of the National Science Foundation. Dr. Picha has been Professional Assistant in the Engineering Sciences Program of the Foundation since September 1958.

The Engineering Sciences program receives and processes research proposals in the fields of chemical, civil, electrical, and mechanical engineering, metallurgy, and engineering mechanics.

NEW FRONTIERS FOR FRESHMEN

Leading scholars and scientists of Harvard joined with selected freshmen last fall in an experiment in "colleagueship."

Freshmen of Harvard and Radcliffe College are doing laboratory research, field work and reading beyond the conventional limits of the first college year and discussing their progress and findings with senior faculty members in small seminar groups and laboratory workshops. The aim is to plunge some of last June's secondary school graduates rapidly into the challenge and excitement of intellectual work in a university.

The year's experimental program is made possible by an anonymous special gift. This permits increased faculty attention to freshmen in small groups, and provides additional rooms, laboratories and workshops where the seminar groups can have their headquarters. For instance, in one seminar and at occasional dinners, Poet William Alfred will guide informal discussions and student writing on literary topics. In another, Metallurgist Bruce Chalmers will assist boys with an interest in electronics and photography in the laboratory investigation of the freezing of water and the melting of ice.

Experimental Educational Television

JOHN L. MARTINEZ

School of Engineering
Tulane University

Experiments in education by television are being conducted in many parts of the country, in and out of schools, by general broadcast and by closed circuits. Tulane University, in conjunction with the Ford Foundation, has presented through WYES-TV, New Orleans, an adult education series consisting of seven weekly half-hour shows in the fields of architecture, engineering, English, history, music appreciation, philosophy, and language (Spanish). The purpose of this paper is to report the experiences of the faculty members who have participated in these programs in the hope that others might find some information here for use in the further development of this medium as a teaching device.

The television instructors, from these varied fields, are unanimous in their enthusiasm for television and its instructional potential. All were experienced classroom instructors and have found this to have been valuable teaching experience and, at the same time, substantially different from class room work.

The purposes of this series of programs (each a half-hour per week for from 12 to 35 weeks) were:

1. To acquaint faculty representing a variety of fields with the TV medium in the most direct manner.
2. To find adaptable faculty.
3. To strengthen the local educational station programming with university-level programs.
4. To permit experimentation in format, visual aids and audience response and to develop an adult following in the area.
5. To serve as an introduction to college credit programming as the adult audience is enlarged.

The instructors who have participated in conducting these courses have noted two important differences between TV and classroom teaching: the "coldness" of the TV medium and the degree of preparation required.

Coldness

The "coldness" or complete lack of student presence and reaction constituted one of the major obstacles to adjustment on the part of the instructors. The lecturer is faced by two or more cameras and cameramen and, usually, a floor manager, all of whom are too busy to pay attention to the material being presented. Incidental noises, instructions to the cameramen and moving about of props add to the lack of scholarly atmosphere.

The professionals in the use of the TV medium stress to the instructors that television communication is intimate to the viewer—as far as he (the viewer) is concerned, he alone is watching. This should be exploited by the speaker and, hence, the programs are delivered largely in the second person and in a tone which would be used in conversation with one person. This requirement—the intimate delivery in a most non-intimate atmosphere—gave the experienced classroom lecturers considerable difficulty.

With the technique used, the lecturers were not allowed to use notes other than the barest outlines. The lecturer's greatest asset is the impression of speaking directly to the viewer and, if he should read his talk, he sacrifices much of the intimacy for which he is striving.

Presented April 2, 1959, to the Southeastern Section of the ASEE at Tuscaloosa, Alabama.

Preparation

The second major difference from classroom teaching was in the degree of preparation required. Preparation time varied considerably from program to program but usually amounted to 8 to 20 hours per half-hour show. The instructor was in charge of planning the show and submitted to the station director an outline consisting of key sentences and the series of visual aids (placard, slides or objects) which should be shown at these times. These outlines were needed 4 to 7 days ahead of time together with a rough sketch of the visual materials needed. The actual preparation of the visuals was done by the art department of the station.

The considerable time of preparation on the part of the lecturer, then, was devoted to the following:

1. Preparation and submission of the program outline and sketches of visual aids required.

2. Practice for timing—not usually done at the station.

3. Consultation with the director, who might have technical suggestions with regard to the visuals or camera sequences.

4. Rehearsing at the station with the visual aids in place. This was done just before the broadcast period.

5. Broadcast period and consultation afterwards.

In order to improve and check on the broadcasts from technique and delivery points of view, a technical advisor from the Theatre Department and another faculty member, who was coordinator of the whole program, monitored the programs and submitted critiques on delivery, interest, technical details and general effectiveness. Periodically, each lecturer was briefed on the portions of these critiques applicable to him.

The time spent by the instructors engaged in these series was compensated for in reduced teaching load, by direct payment or, if done as an overload, by accumulated leave. In general, direct payment was avoided. Instead, the particular department was asked to release the instructor from some classroom duties and the department was paid from the television fund for that portion of the instructor's time. When carried as an overload, the instructor was assured of equivalent time released from a later semester or, possibly, a paid leave of absence if he should accumulate sufficient released time.

The standard for determining equivalent time was in the proportion: one half-hour TV program to one 6 credit hour classroom course. Later, and with credit programming consisting of two half-hours per week, this will be increased to credit for teaching 9 or more credit hours in the classroom. The degree of preparation associated with the TV work seemed to justify the equivalents.

It was expected that some adjustment to TV delivery would be necessary. Accordingly, the program coordinator and technical advisor worked with each instructor in an indoctrination program including making kinescope recordings at the television studio. These introductory procedures required from 30 to 50 hours of preparation, delivery and viewing of kinescope recordings on the part of the instructor prior to his first show. The instructors agreed that this indoctrination was very helpful in adapting to the television routine.

Some of the reasons for the great amount of preparation time in comparison to typical classroom practice were:

1. Better preparation. The released time from classroom work enabled the instructor to prepare his lecture in greater detail. More reference was required in selecting suitable visual materials.

2. Submission of outline and visual sketches. The fact that others had to know of his specific plans meant some formalizing of outline and submitting of complete sketches or selections from references of all visual materials.

3. Timing. Since the broadcasts are part of a full televising schedule, almost exact timing is required. This is achieved by practicing with the outline and copies of the visual aids. During the broadcast, visual signals are used to let the instructor know the time remaining at any moment.

4. Coordination. While the instructors had complete freedom in planning the shows, of necessity coordination between the instructor and the art department and the station director resulted in some calls and conferences. This small loss of independence was more than offset by the feeling of joint effort and combining of skills in "putting across" the material.

5. Language. Some practice was necessary to achieve and maintain the intimate tone and delivery in place of the usual classroom delivery. Use of the second person and choice of language suitable to adult groups of mixed scholastic backgrounds required a conscious effort on the part of the instructors.

6. Sense of responsibility. While all teachers feel a great sense of responsibility in the preparation of classroom material, the factors of knowing that the audience is numbered in thousands and that the efforts are focused into the final delivery gave the instructors incentive to prepare especially well.

The instructors in these varied fields each became convinced that his subject can be televised effectively for instructional purposes.

Contributions of Television

Teaching by television has certain unique features to offer to the educational field. Besides being the only means of reaching large numbers effectively, there is a degree of intimacy between teacher and student which is lost in motion pictures and sometimes lost in large classes.

While televised instruction is developing rapidly, the method will not be used in a large percentage of college courses for some time and there will always be courses that are not economically feasible for TV presentation. Many TV techniques, however, could be effectively applied immediately to present classroom procedures. I believe that the use of a good graphic arts department is an important possibility; the use of the precisely prepared lecture is a related one. A classroom teacher could prepare his outline, sketch any illustrations which he might care to use, and submit these sketches to the arts department. Several days later when he went to class, a neat stack of well-prepared placards or slides would be waiting for him. The classroom time spent in making fewer, poorer illustrations could be spent in discussing the well-prepared visuals instead. Copies of the rough outline of the visuals submitted to the art department could be reproduced and distributed to the students so that they could watch and listen instead of taking notes. The same thing could be done with the lecture outlines.

Other possibilities present themselves. These same lecture outlines and visuals could be used by lecturers in other sections as a means of achieving consistency of coverage or as an instructor-training device by having a young teacher observe and adapt himself to the organization of material by the better, more experienced teachers.

These experiments in educational television have achieved most of their goals. There has been a radical increase in the following of the educational station in this area—in direct competition with commercial stations in the early evening hours. Most of the instructors have adapted to the medium and become enthusiastic about its potential. The medium has proved itself adaptable to a wide range of types of material—from the technical to the metaphysical—from engineering to philosophy.

Special Feature in May:

ENGINEERING EDUCATION IN OTHER COUNTRIES

The Effect of the National Defense Education Act on Engineering Education

K. L. HOLDERMAN

Coordinator of Commonwealth Campuses
The Pennsylvania State University

When the present National Defense Education Act was being considered in the Congress—along with a rash of other educational bills—it was referred to as an "omnibus bill." These are words that at least imply that the measure is made up of a miscellany of related, or perhaps unrelated, separate bills or ideas. Having followed the hearings that were held on educational matters during the second session of the 85th Congress and having reflected a little upon Public Law 864 (the NDEA), a measure that presumably grew out of those hearings, I get the impression that the integration of the several titles that now exist was accomplished with a paste pot and brush rather than by good engineering principles of design.

The National Defense Education Act was passed because many of the members of Congress believed that it was needed to take care of an emergency. In fact, the second sentence in the statement of purpose for the act mentions the demands of the "present emergency." The declaration of policy for the Act then calls for improvement of education relating to science, mathematics, foreign languages, and technology. The principal reason for this legislation was the growing alarm throughout the nation that our technology was lagging and that our total program of education in engineering and the physical sciences wasn't what it should be. The Act was "sold" to the Congress on the need to strengthen engineering and technological education. Ironically, the opinions of most knowledgeable educators in these fields were not accepted, nor were their ideas included in the measure. Hence, the Act has had little direct effect thus far upon engineering education. Before proceeding, let me say that I do not believe this misdirection is the fault of any individual or any group of people; it is probably just inevitable in a democratic system of government.

In my hand is a copy of the hearings that were held before the Senate Committee on Labor and Public Welfare prior to the enactment of Public Law 864. A somewhat thicker volume was generated from the hearings in the House. I'm sure that all these words do not reveal any finely delineated national educational need. Rather, this presents a bewildering montage of somewhat unrelated educational needs, regional differences, and a few special interest pressures. But from this testimony and with a gentle guiding hand from the U. S. Office of Education we, as a nation, have given birth to legislation that may have profound effect upon our educational system and, perhaps, our very way of life in the future. Let's examine it.

Title I of this law provides a statement of findings and a declaration of policy which seems to relate it closely to engineering needs. Then it includes the usual list of definitions, most of which could be considered beyond controversy. However, there is one definition that, if allowed to remain in the law in the future, will have lasting effect upon engineering education, engineering practice, the utilization of engineering personnel,

Presented before the Engineering Division, American Association of Land-Grant Colleges and State Universities, November 10, 1959, St. Louis, Missouri.

and indeed, perhaps the whole social and economic structure of the country. Public Law 864 defines an institution of higher education as one that admits high school graduates in programs approved by the States as being beyond secondary education and (here is the hooker) "provides an educational program for which it awards a *bachelor's* degree or provides not less than a two-year program which is acceptable for *full* credit toward such a degree." The definition then goes on to include requirements for non-profit status and accreditation.

Why is this important? For more than a decade, since World War II, it has become increasingly evident to most industrial managers and many government officials that we must make better use of our scientists and engineers, and to do so we will certainly require an increasing number of educated engineering technicians as supporting personnel. Engineers have become convinced of this fact. Most of our important engineering bodies have made important declarations concerning this matter, and in some cases, considerable effort and the financial resources of engineering societies and engineering institutions have been expended to "sell" the idea of the engineering technician and better utilization of professional personnel. Another fact has become abundantly clear during the past ten years. The kind of education needed to prepare an engineering technician is that provided beyond the secondary school level through approximately two years of higher education. Now we come to a fact that seems to be so difficult for those of us in engineering education to explain to our colleagues in other disciplines. An engineering curriculum, whether at the professional or semi-professional level, is highly sequential in course structure and is developed on a mathematical and scientific base adequate to support the more specialized applied topics. This mathematical and scientific base differs considerably for professional curricula in contrast to those programs designed to prepare engineering technicians. It is not possible to organize adequate programs at a sufficiently high technical level to prepare the needed semi-professional personnel and at the same time have all of the courses "acceptable for full credit toward a (baccalaureate) degree"—at least, not in engineering.

If this definition of higher education is not altered in future versions of the Act, two different effects may be felt—one far more critical than the other. First, many institutions may resort to the "gimmick" of establishing the fact that courses designed to prepare engineering technicians are transferable to baccalaureate degree programs in fields other than engineering, as an example, industrial arts or vocational education. This is perhaps a possible subterfuge but causes confusion and misunderstanding as well as surrounding the important education of engineering technicians with a shroud of gobbledygook and second class status. Before discussing the other and more serious possible effect of this ill-conceived definition, let me first quickly review the several other titles of the National Defense Education Act and touch upon their possible effect on engineering education.

Title II provides for loans to students in institutions of higher learning with special consideration given to those preparing to teach in elementary or secondary schools and to those with superior capacity in science, engineering, and foreign languages. These loan funds, unquestionably, will benefit thousands of students and enable many to get an education or continue their education who would not otherwise be able to do so. Presumably a fair share of these loans will be made to engineering students, some with superior ability. It should be recognized, however, that in recent years many independent sources of financial aid have been available at most engineering schools for *superior* students. Further, it should be noted that most engineering educators have considered the problem of the quality, not the quantity, of students as being of greatest concern. Title II will have some beneficial effect upon engineering education. It is interesting to note, however, that 50% of the loan of graduates who enter elementary or secondary teaching can be cancelled over a period of five years, but no com-

parable "carrot" is held out to those whom we may encourage to enter the field of engineering education. The biggest single problem in engineering education today, where are our faculties coming from, is given no real, important, direct help from this title of the National Defense Education Act.

Title III provides assistance only for secondary schools to strengthen work in science, mathematics, and foreign language instruction. These funds undoubtedly should have some indirect beneficial effect upon engineering education. Our reading on this effect will never be an accurate one and cannot be made for several years. I believe most of us will agree that many of our secondary schools are improving—and improving fast. This improvement may be helped or speeded by the National Defense Education Act.

Title IV provides graduate fellowships. In the first year of the act—ending last June—1,000 fellowships were awarded, 65 of which were in engineering. If these 65 persons eventually enter or remain in engineering education, we are benefited. However, it should be noted that there are perhaps more serious deficiencies in engineering faculties than in any other field, and with approximately 8% of the total number of undergraduates now enrolled at higher institutions matriculated in engineering programs, only 6.5% of the fellowships were awarded to those preparing in engineering studies. For implementation of legislation that was "sold" on the national need for more engineers, this should cause some eyebrows to be raised.

Title V provides assistance for work in guidance and counseling of students. Grants are made to both state educational agencies and institutions of higher learning. The long range benefits of this program may affect engineering education. Certainly if we could limit our resources and attention to only those students who are sure of profiting from an engineering education, we could be more effective. This title, along with *Title VI*, which provides help in foreign language development, the *Title VII*, which provides for more research in the use of television and other related media, may eventually help engineering education. The effects, however, will be peripheral rather than frontal in the attack on problems relating to technological education.

Now we come to the much discussed and controversial *Title VIII*. This section of the Act has some possibility of seriously affecting engineers, engineering education and our whole engineering-based economy. First, I'll assume that we are all somewhat familiar with the history and development of vocational education in this country. World War I caused the enactment of the original Smith-Hughes Act of 1917 recognizing that our country needed a better system of preparing not only artisans, but all kinds of production and service workers. Since then there have been numerous changes made in the Federal laws to broaden the base of vocational education. However, the original concepts of vocational education have not been altered, namely that it is instruction to be conducted basically at the secondary level and described in all vocational education legislation as "work of less than college grade." By traditional interpretation of the U. S. Office of Education, however, "work of less than college grade" is any instruction not leading completely to a bachelor's degree.

During the last several sessions of Congress, bills have been introduced and reintroduced to broaden the base of vocational education still further and make possible not only the establishment of so-called area vocational schools (comparable in purpose to the jointures in high schools), but to train people for employment as technicians in scientific or technical fields. This latter function is to be performed, mind you, with instruction of "less than college grade."

Title VIII of the National Defense Education Act was a last minute addition to the law. It was a warmed over version of an earlier bill that had been before the 84th as well as the 85th Congress. It was attached to the so-called omnibus bill after considerable backing from the American Vocational Association. However, let me tell you why, in my opinion, it will not adequately support the technological defense of our na-

tion, which is the basic purpose of the Act.

Without getting into the semantics of the word "technician" let me state that one of the real needs in the country today is for more well-trained engineering technicians. In fact, these technicians—the engineering technicians—are the employees who may have a real contribution to make to our national defense. What are engineering technicians? They are the trained and educated personnel who work in supporting positions with engineers and in semi-professional activities in many engineering-based industries. How are they prepared for their positions on the engineering team? By an educational experience beyond the high school, usually two years in duration, in a rigorous program conducted with the philosophies of higher education. The vocational schools with the help provided by *Title VIII* may train more technicians that are highly skilled, but they will not be educating the engineering technicians that are so urgently needed in our present engineering and scientific manpower spectrum. Traditionally the emphasis to a great extent in vocational education is on repetitive manipulative skills. That is not the urgent need today. An engineering technician is usually required to perform some skillful tasks, but his real contribution is his knowledge of engineering principles and practice. Vocational education has not demonstrated an ability to provide this kind of education.

In all probability the funds that were made available under *Title VIII* are needed to enhance the existing work in vocational education. I do not profess to know anything about these needs. I do know something about the employment needs of industry as these were reflected in a recently completed study of technical institute education. *Title VIII*, as now enacted, will not do the job, will not fill the positions; nor will it benefit engineering education, although engineering education, particularly at the technical institute level, must be expanded and improved.

I should like to propose that the engineering educators point out this important fact to the proper committees of both houses of Congress and strive to have some of the benefits of the National Defense Education Act directed to a program that will help prepare more and better engineering technicians—persons genuinely needed in our defense effort—and needed to develop intelligent engineering manpower utilization practices.

I have not intended to be super critical of the National Defense Education Act nor the spirit in which it was passed. I believe that more public support for higher education is absolutely essential and this support probably must be provided by the Federal government as well as through local and state financing. Let's use our energies, however, to help develop practical programs of support that will enable a tax payer to get the greatest benefit from his dollar. I hope the National Defense Education Act will be amended in the next session of Congress. Further, I hope engineering educators will be helpful and articulate in providing suggestions as to how the Act might further assist in the development of a sounder system of engineering education—at the several different levels, all of which are needed to support our defense requirements and our growing national economy.

ANNUAL MEETING

Purdue, June 20–24

Where Do We Get Our Ethics?

STUART W. CHAPMAN

Professor and Executive Officer, Department of Humanities and Social Studies
College of Engineering, University of Washington, Seattle

Our joint concern about the teaching of ethics is easily understandable, for we live in a culture where many people have cut loose from the certainties of the past. Religious sanctions for moral standards have lost some of their old force. The fixed universe, sheltering a mankind with known goals and a clearly lighted and posted road to those goals, has given way to another of incomprehensible size, and of ceaseless movement. In it the destiny of man cannot be read clearly.

And our culture, once impelled by ideals of individual worth and self-realization, has now become a mass culture in which the individual has increasing difficulty in finding his own place and in resisting the pressures which would make him like all other people. (This in spite of the fact that there are actually more opportunities for self-development than ever before in history.) The material wealth of our culture seems to emphasize the importance of things and to diminish the worth of spiritual values.

We might as well admit, then, that our concern with teaching ethics may be part of a more general search for certainty in a world which is often confusing, frustrating, and terrifying. And we should recognize a danger: that in our search for certainty we will try merely to teach a "code" of ethics as we teach the principles and processes of mathematics and thermodynamics. When we teach ethics we may teach a fixed decalogue or duodecalogue, formally and officially adopted by a professional organization, which we bravely try to transfer from the graven stone tablets to the *tabula rasa* of the student's mind.

Yet there are many things about ethics which make it doubtful that we either can or should teach it in this way.

What is ethics? Some call it the science of values; others a branch of philosophy dependent upon metaphysical theory; still others, as I have already suggested, see it as a set of hard and fast rules, established by authority and requiring obedience of all "good" people.

But an attempt at a formal definition of ethics will probably get us nowhere. So let us say that ethics involves values, certainly; that in accordance with the values in a system of ethics the individual makes choices between good and evil, right and wrong, better and worse; that ethics involves action, not merely preachment, that ethics is indissolubly a part of character and personality. In other words, when we undertake to teach ethics we deal with some of the most important elements which distinguish man from other forms of life.

If we would teach ethics, then, we must consider seriously where we get our ethics and then go on to see what those facts imply.

From the Beginning

Suppose we ignore as too controversial and uncertain the possibility of inherited predispositions toward certain attitudes, and actions growing out of those attitudes. We can still say that the construction of the individual's ethical system starts no later than the moment of birth. Ethics involves attitudes toward

A paper given before a joint meeting of the Ethics, Humanistic-Social, and Relations with Industry Divisions of the American Society for Engineering Education, June 16, 1959, Pittsburgh, Pennsylvania. Recommended by the Ethics Committee.

people; beliefs about what one should do are affected by concepts of what people are like and how he is related to them. Such attitudes and beliefs, choices of end-goals, reactions to human situations, proportions of love and hostility—all these are early conditioned by the kind of treatment the infant receives, by the amount of affection bestowed and withheld, and by the degree of self-realization permitted and forbidden.

For a considerable time after birth the individual's ethics are more formed from without than grown within. Family standards incarnate in a warmed posterior or spiritualized in a shamed ego, social standards sanctioned by a nose bloodied by one's playmates, or enforced by the pressures of the cub scout pack, or made holy by the Sunday school—these become parts of the ethics of the individual.

Of course, as the child grows he rationalizes his ethics more. He learns something about ethics when he sees the respected neighbor walk back home with the piece of plywood he has just taken (of course, not stolen) from the construction project down at the corner. He learns ethics when he sees what kinds of people are held up for admiration by the press and TV. He acquires standards from all those whom he has been taught to admire and from those he has been taught to hate. Indeed he acquires standards just in the process of being taught to hate as well as to love.

Yes, the child learns ethics in the school, not always because ethics has been consciously taught, but because he sees what standards are upheld, and who are the heroes of his fellow students; he becomes aware of who can get away with what and for how long, and learns to apply new knowledge (great or small) to an evaluation of the standards he has held. It is no exaggeration to say that the individual acquires his ethics from every experience which involves values, from the bawling out which follows the spilling of the milk to the thrill of great music and the understanding and revelation of new truths expressed directly or symbolically in fine art.

Implications important for the teaching of ethics flow from this interpretation of the ways in which we get our ethics.

First, we need to remember that just as the personalities of our students have been pretty well formed by the time they enter college, so also have their ethics. Indeed, few elements in their lives have crystallized more in the course of their sixteen to twenty years; the only other comparable one that I think of is their use of language. Since human beings cannot live without standards of action, our students do not come to us as non-ethical beings who must now be taught ethics, but as definitely ethical humans—whether we always like their ethics or not. It follows that when we try to teach ethics at college, we are tackling one of the hardest jobs we can.

Second, our students come to us with ethics which are not based entirely upon reason. Growth through infancy, childhood, and adolescence has exposed each one to many experiences which have stirred in him strong feelings, intense loyalties, and perhaps just as strong hatreds. Ethics are not only intellectual but also emotional; not merely mental but also visceral. Indeed, the efficacy of a code of ethics is probably just about proportional to the depth of the individual's emotional attachment to it. When we undertake to teach ethics at the college level, then, we undertake to deal with mind and emotion, inextricably connected. We deal with the whole personality. Rational conduct of rational courses, running three hours a week for ten to fifteen weeks, will hardly be enough to do the total job which we may think needs doing. That is, if we hope to have our teaching bear fruit in changed living as well as in passed quizzes.

Third, our students come to us with ethical systems which, consciously or unconsciously, are based on some act of faith, unprovable perhaps but still meaningful and useful to the individual. This act of faith may involve a supernaturalistic interpretation of the universe and man, or a naturalistic one; a democratic attitude or an authoritarian one; a materialistic or an idealistic outlook. In any case, when we teach ethics, we involve

the most fundamental commitments a man can make. This is a serious matter which should be undertaken with the greatest of care and sensitivity.

Last, our students are actually learning ethics from all their college experiences. Each one of us "teaches" ethics. A disclaimer of responsibility or intention cannot change that fact. Each one of us preaches at times; each of us exhibits his own values by the rewards and punishments he hands out and by the stimuli which occasion them. Each exemplifies his ethics in his conduct of classes and in his relations with students. The engineer or scientist may show his respect for intellectual integrity by the way he teaches, but he will not necessarily do so just because he is teaching science. Indeed, he may help to teach high standards of social conduct by his own behavior, even though the substance of his course seems at first glance to have nothing to do with social values. On the other hand, the teacher of humanities may or may not encourage humane values in his students. The subjects of the courses in themselves are no guarantee of results. Intellectual content may be nullified by the attitudes and methods adopted in its teaching.

Responsibility of All

When we talk about teaching ethics, then, we need to realize that we are talking about a job which is a responsibility and opportunity for all of us. No one can escape it any more than he can the burden of teaching English. For good or ill, man is an ethical creature. He acquires his ethics by reason and feeling, by conscious experience and by "osmosis." Changes in his ethics are as apt to come by observing people he admires as by listening to preachment. We, as teachers, everyone of us, are in positions where we may become subjects of admiration, unconcern, or dislike. Ethics become inescapably some part of our product.

At this point I had better enter a disclaimer. Unless I do, someone will surely feel that I have made a plea to forget all about teaching ethics, and in particular that I am opposed to courses in ethics because they can be of no earthly or heavenly good. But such is not the case.

Probably most of us can remember college courses which had an effect upon our lives, or know students who have come to new appreciations and to new ways of thinking and acting as a result of college courses. A course in ethics, whatever its possible limitations, certainly can be productive of such results. In it the student can concentrate on a study of values by explication, not just by implication; he can compare different ethical beliefs and the effects which flow from their practice; he may become aware of the assumptions, hitherto largely unconscious, which underlie his own beliefs; he may realize the inconsistencies of his own ideas and take steps to develop a more coherent philosophy. For such reasons I am willing to assert the desirability of courses in ethics.

However, as we undertake to develop and teach such courses, we should, I think, remember the following: (1) we shall be dealing with a basic and sensitive area of human life; (2) we must concern ourselves with problems of values of all kinds, not just with particular codes of ethics already established by some authority, professional or otherwise; (3) we should not expect a course in ethics to do the whole job of teaching ethics, and as a result, ignore all the opportunities for such teaching which reside in other courses and in all the activities connected with college life; and (4) we must not expect courses in ethics to cause a moral revolution in the college population.

Our ethics come from many sources, of which the course in ethics can never be more than one.

A Proposal for the Unification of Student Engineering Societies

FRANK KREITH

Professor of Aeronautical Engineering
University of Colorado
Boulder, Colorado

PRESTON PARR

Associate Dean of Students
Lehigh University
Bethlehem, Pennsylvania

The Problem

Student sections of engineering societies are ailing. They are not achieving their primary objective, the development of a professional interest and attitude, and indeed many of them lack any well defined goal and program.

The symptoms of the illness are well known: meetings are poorly attended by both students and faculty, programs are uninspiring and burdensome to plan for, and over the months and years both student and faculty interest—to say nothing of enthusiasm—tend to decline.

Artificial remedies, such as incorporating the activities of the student sections into the formal educational program or departmental attendance requirements at meetings, are in the long run incompatible with the very attitudes the societies seek to develop.

Diagnosis

We believe the failure of the societies has several sources. First, the curricular trend in engineering education is in the direction of increasing unification of the early years in college. The uniform freshman year is common, in the sophomore year the curricular differences among the fields of engineering are slight, and even in the junior year more and more subjects are taken by all engineering majors. The tendency to make undergraduate engineering more liberal (in the sense of including required courses and "distribution" electives in the humanities and social sciences) and scientific (as opposed to strictly technical) argues more for uniformity than diversity. The fragmentation of engineering societies along departmental lines represents, therefore, a lag behind the current stage of curriculum development.

Second, the programs of engineering societies are not infrequently merely an extension of technical courses. Attendance requirements (where they exist) suggest as much, and all too often the lecture of the visiting speaker smacks of the classroom—unless, of course, he comes from industry and faces the dual problems of interesting a general audience in a highly specialized subject and of delivering the talk at the right level. When society meetings do not afford an interesting change of pace, they are in danger of becoming an additional burden to the student whose work load is already so heavy that he rarely continues as a matter of curiosity beyond a given assignment lest he neglect another. If the speaker uses the meeting as a recruiting device, the students may properly ask why the society's funds were spent to bring him to the campus.

The third point is, in a sense, another way of looking at the second. A principal reason for the common lack of a well-defined objective of engineering societies is that "professional development" is often thought of only in terms of increasing one's technical competence. We submit that there is more to being professional than having technical expertise; professional people are, or should

be, characterized also by a sense of vocation, that is, an attitude toward their professional work and its place in society.

Finally, engineering societies for students are often conceived on the basis of unrealistic assumptions about the nature of undergraduate life, particularly that of engineers. In an otherwise laudable desire to set high professional standards and to use the societies as a means toward that end we are sometimes blinded to the facts that:

(1) Engineering freshmen are 18 years old and seniors only 21. The characteristics of students in this age group are not those of the 21–30 bracket (where professional training in law, medicine, and other fields is pursued *after* the undergraduate years).*

(2) Many undergraduates in engineering, including some of the best, are still exploring vocationally during their undergraduate years and are unready to commit themselves wholly to becoming, say, mechanical engineers in the same sense that the medical student commits himself to becoming a physician.

(3) Most undergraduates, including engineers, are still coming to terms with intellectual and social attractions which are both inevitable and praiseworthy in themselves but which are not conducive to that single-minded pursuit of a chosen field of engineering that many societies at present assume.

Suggested Solution

In looking over the present practice of having many different student chapters of professional engineering societies on a campus, one is immediately struck by the similarity of their problems. It is, therefore, only natural to ask whether it would be possible to pool the resources of the local societies on a given campus, stress their common interests, and evolve a single organization which would better serve the needs of the students and also advance a high standard of professionalism among engineers without infringing the special needs and interests of the individual *parent* organizations (e.g., ASME, AIChE).

We shall first consider the advantages a single student engineering society might offer to students, the faculty, and the engineering profession and then look at some of the objections which might be raised.

It is immediately apparent that a single society for engineering students would have a much larger reservoir of potential members than any single specialized group. This results, however, not only from combining the memberships of all the individual specialized groups, but, more importantly, because the uncommitted freshmen and sophomores could also join and participate in the activities of a unified group. An increase in membership would probably assure a larger attendance at meetings—especially if the programs were designed to meet the needs of a group of future professional engineers, not of technical specialists. With a respectable attendance figure established, there would need be no hesitation in inviting a man of national reputation who could speak with authority on topics which require a broader view and a more mature outlook than it is possible to expect from a speaker who would be available to address only a small group. Pooling of financial resources would also permit invitations to men not associated with industry who might need reimbursement for their expenses. (Such men might be faculty members of another institution, governmental employees, or consulting engineers.)

An arrangement along these lines, involving a broad cross-section of campus organizations, has been tried with great success in recent years at Lehigh University. About three years ago, examination

* The heady experience of being treated as an adult often comes for the first time with going away to college, and it takes many students all four of the undergraduate years to begin to think and behave consistently as adults. Stated differently, it takes time to come to know ourselves, and for most of us the process is absorbing. Only within decided limits can faculty legislation or institutional pressures speed the process; while it is going on, it is asking too much to expect undergraduates to have the attitudes of mature students of the other professions.

of the calendar of events showed that a multitude of separate campus organizations vied every day with each other for attendance at meetings. The quality of the meetings was not uniformly good, partly for reasons similar to those cited above. To overcome these difficulties and to raise the level of extra-curricular programs, a number of organizations pooled their resources, decided on topics of broad, common interest, and invited eminent authorities—who were also screened for their public-speaking ability—to come to the campus. Typically, the visitor spends the day on campus in the department of his special interest, gives his lecture in the evening, and afterwards attends a coffee hour to which both students and faculty are invited. To date this "co-operative lecture series" has been quite successful and could serve as a model for the proposed unified engineering society for undergraduates.

Although the arrangements for a unified engineering society meeting would be time-consuming and taxing, one such meeting would serve the needs of a large number of students. Faculty resources could be pooled and possibly some sort of recognition of participating faculty could be given by the administration of the college.

The basis for organization is only part of our concern. Of at least equal importance is the society's program.

As we made clear above, there is no justification for having a narrowly technical program; such programs are as unnecessary as they are unsuccessful. Rather, we propose that the society devote its program to providing the background information and discussion that will encourage the engineering student to develop interests and attitudes appropriate to a professional man. What we have in mind can best be illustrated by the following suggestions of representative topics for meetings:

1. Job Selection: What Are the Relevant Considerations?
2. The Pros and Cons of Unions for Engineers.
3. Consulting as a Career.
4. Automation and the Engineer's Future.
5. Professional Ethics: Consultant and Client; Employee and Employer; etc.
6. Engineering Education in the U.S.S.R.
7. In What Sense Is the Engineer a Professional Man?
8. The Relationship of the Supervising Engineer to Labor.
9. The Organization Man.
10. The Art of Invention.
11. Topics in the History of Science and Technology.
12. Registration of Engineers.

At first glance many of these topics appear suitable only for a student bull session, principally because they are concerned with values and opinions and not with the solid facts and theories of technical courses. But reflection will show that the issues thus raised are inescapable for the thinking professional man, and what better time is there to raise them than in the undergraduate years when discussion can be disciplined by the knowledge and experience of older men in a wide variety of engineering and other fields? We believe that the interest of students in such topics is far greater than in the usual engineering society's program.

What is the intended result of such a program? We believe it to be the development of a greater awareness and sophistication in the student. He will be led to consider himself as a professional man in a number of relationships: (1) to the organization which employs him, (2) to other groups with which he must work, (3) to a rapidly changing and expanding technology, (4) to a society which needs, depends upon, but does not understand science, (5) to other engineers with whom on some things he has a common cause. Since these issues cannot be avoided and it is healthy to face them, they should be discussed with others in one's profession—for to do otherwise would be often to substitute ignorance for knowledge, prejudice and stereotype for fair and reasoned judgment. And without some degree of consensus on some of these issues among engineers

in all areas of specialization there is little hope for full professional status for any engineer.

What are some objections which might be raised against a unified engineering student society? The most serious one is probably that such a society would not have a parent organization and therefore could not provide for continuity in membership after graduation. This, however, would not be a necessary consequence of the unified student group. In most institutions some sort of specialization in a particular field of engineering is required or at least encouraged in the junior or senior year. At the time specialization begins the student should be encouraged to affiliate with one of the founder organizations (ASME, AIME, ASCE, etc.), and indeed such affiliation should be regarded as part of his professional responsibilities. (For that matter, there would be nothing that would preclude the advanced students in, say, civil engineering, from meeting together on occasion, but as a regular thing we think such a practice is neither necessary nor desirable.) When the new United Engineering Center is built, the degree of cooperation among the specialized branches of engineering should increase and could thereby facilitate the operation of a unified engineering student organization.

Another objection might be that professional development is better accomplished in special courses in existing engineering curricula. We know of several engineering departments which offer a one-unit course on professional development for senior students. Although such a course with fewer students offers a chance for personalized attention and discussion, we question whether the academic apparatus of assignments, quizzes and grades is appropriate to the objective. Responsible attitudes and concerns can no more be taught in the classroom than good behavior can be taught in an ethics course. Concerns are shared, not taught; attitudes develop in a climate, not through the academic apparatus. Moreover, within a special curriculum the same instructors who teach the technical aspects of the field lecture the students on professionalism, whereas under the proposed scheme new faces, including those of men who can speak with the authority of other relevant disciplines, will be available to lead discussions. For that matter, a great deal of the programming could be and should be placed in the hands of the students.

A final objection might come from those who value the fellowship centered around a common interest, e.g., bridge design. Our answer is that the issues we raise are of interest and common to all engineers, regardless of specialization. Further, fellowship within narrow and special interest groups rarely needs institutional support; it develops inevitably, and in the years after graduation it will be fostered through the founder organizations. The function of the undergraduate engineering society is allied to the purposes of undergraduate education: it should broaden the student's experience and acquaint him with the fundamental principles and issues of his profession.

We think it would be instructive for engineers to examine the medical profession, which enjoys far greater prestige than engineering with the general public. Although it is commonplace for engineers to complain that they lack the professional status of physicians, they fail to recognize that the American Medical Association, to which all physicians belong, is a principal instrument of the professional solidarity which leads to the physicians' status. Despite the revolutionary advances in medical science which call for greater and greater specialization by practitioners, physicians recognize that *as professional men* there is more that unites them than differentiates them. Engineers, on the other hand, have tended to think of themselves in vocational isolation.

In closing, we must admit that it is often easier to point out present defects than it is to come up with new plans which are themselves without flaws. In discussing our ideas with others we find little disagreement with our statement of the problem, general agreement with the diagnosis, and some willingness to accept our general proposal for a solution. We argue that a unified undergraduate so-

ciety along the lines we have suggested is realistic in terms of undergraduate life, the trend in curricular developments, and the need to enhance professional status. It will pave the way for later affiliation with the founder groups and strengthen the bonds which are now developing between those groups.

CANDID COMMENTS

Wither ASEE?

As an active member of the Relations With Industry Division for a number of years, I have been concerned with the lack of willingness of ASEE to clarify its role in engineering education. The Society fluctuates between the pinnacle of an occasional outstanding contribution to the depths of lethargic interest.

RWI is conducting a study under the chairmanship of Paul Robbins to evaluate the objectives of its own activities and their worth to the Society. In some recent correspondence with the chairman of this committee, I made the following statement:

> The longer I am affiliated with ASEE, the more I am impressed with its potential ability and perhaps even obligation to contribute more substantially to engineering education. Here is a framework of outstanding educators supported by industry which has the latent ability to make itself really felt in the engineering educational field. Many of the studies and work which are now being done by many other groups on a fragmented basis could at least be integrated by ASEE. Either ASEE is negligent in accepting this responsibility, or perhaps the group does not wish to assert a more vigorous role in education.

We in industry are constantly vexed with the confusion regarding the status and future of engineering education, both in industry and the colleges. While there is a great deal of action in the arena, there appears to be a lack of integration for a proper interpretation of the scene. ASEE, because of its size and broad representation in educational circles, certainly could take continued and positive leadership in making sense from the many gyrations in engineering education —if it has the desire.

DONALD E. IRWIN
Chairman, Relations With
Industry Division

Physics and Engineering Education: Complementary or Supplementary?

RAYMOND J. SEEGER

National Science Foundation

We all live in one world; all of us look at the same things, at planets, at plants, at people. Each one of us, however, looks at the world from a different point of view, now that of aesthetic enjoyment, now that of philosophical relatedness, now that of technological use. Our individual views, moreover, are somewhat unclear and indistinct. Overlapping occurs necessarily, owing to inherent interrelations. Architecture, for example, may be regarded either as a fine art or as a practical art. Poetry, in turn, may be looked upon as a fine art or as a liberal art. Even science may be considered as a liberal art or as a practical art. All three viewpoints, I believe, must be involved in any education, though one of them will generally be dominant. Thus we speak colloquially of literary education or of scientific education or of technological education. The genuine educational picture must comprehend all these viewpoints in a coherent, broad beam. It will not suffice to have three narrow beams. The basic curriculum question, therefore, is not simply the number of hours for the humanities, or the number of hours for the sciences, or the number of hours for technical subjects; but rather the overlapping of these very subjects qualitatively as well as quantitatively. In this regard I am reminded of a recent image presented by the physicist Werner Heisenberg.[1] The teacher, he visualizes, is a person who focuses light upon a landscape, which begins to glow of its own accord until it finally brightens the entire outlook of a student. On this basis, physics must necessarily be involved in engineering education. Engineering, in turn, must properly be included in physics education. These are not supplementary subjects that can be added or subtracted at will; they are naturally complementary, forming a whole, cultural picture.

A perennial, practical question on the college campus is who should rightfully teach what; who should teach mathematics to physicists? Who should teach physics to engineers? For two cogent reasons I would argue strongly that physics qua physics should be taught by physicists.

Logical Structure

First of all, the logical structure of physics will be emphasized by the creative physicist who is daily concerned with planning and building it; the very scaffolding will be helpful to the student in outlining its historical development. Just recently I heard some criticism of the teaching of plane geometry in certain secondary schools. It seems that Theorem A was being taught on Mondays on the basis of Theorem B, whereas on Tuesdays Theorem B was being proved with the aid of Theorem A. Such circular reasoning results from a failure to emphasize logical structure with its axiomatic beginnings. What is more, if one does not have a clear picture of logical connections, there will be a tendency to regard the sum total as merely a collection of independent formulae and not as an organic whole. We are sufficiently handicapped by the limitations of our own minds and the complexities of phenomena themselves without adding artificial barriers to our understanding of the universe.

The physics teacher can provide engineering students with a comprehensive, universal outlook, a second important

[1] Werner Heisenberg, *The Physicist's Conception of Nature*, transl. A. J. Ponerans. Harcourt, Brace; New York, 1958.

Luncheon Address, ASEE Physics Division, University of Pittsburgh, June 1959.

contribution. The engineer is necessarily close to urgent tasks and immediate interests; he does not always feel free to encourage marginal serendipity. In stressing the present common-sense approach he may even forget that this very intellectual area was the science frontier of yesterday, that today's frontier will become common sense tomorrow. Pure science, because of its wide view and its far outlook, enables students to see beyond the horizon.

Let us examine in more detail how physics might be taught to engineers. What I am recommending is the teaching of physics without intellectual blinders, without any attempt to keep one's mind focused upon present problems. I should like to illustrate my argument with three examples.

First we shall consider the Copernican theory,[2] which is certainly useful to modern engineers in connection with satellite orbits. In this instance, what is our attitude toward observed data? Do we actually compare them with present mathematical analyses? Do we urge students to trust Copernicus' reasoning in preference to Ptolemy's observations? Do we insist that although we see the sun rise, we know that the earth is moving? We observe strictly only an increase in the distance between the sun and the horizon, as when a train seems to move relatively to another one supposedly standing in a station. As for astronomical data in the time of Copernicus, the Ptolemaic and Copernican theories, as well as Kepler's later modification, were all equally satisfactory. What, on the other hand, is our disposition toward theory itself? Do we insist that the one planetary system is nowadays correct, but the other not? Or do we note that both descriptions are equally valid depending upon the center of reference? The sun, of course, is practically a better center of reference for problems involving the solar system, but it is hardly convenient for astrophysical questions. What about the "true" theory? Do we make Thomas Aquinas' distinction [3] between a deduction from intelligible principles and an inference from scientific observations? Do we, too, prefer the former to the latter? Incidentally, the Ptolemaic theory was not philosophically true even at its inception, inasmuch as it involved epicycles and eccentrics. Francis Bacon, indeed, preferred the Ptolemaic theory because it seemed to agree with the current common-sense philosophy. Galileo Galilei, on the other hand, insisted upon adjusting theoretical principles to physical phenomena—a radical viewpoint in those days. With his deductions from first principles of physics themselves, Isaac Newton alone may be said to have established the Copernican theory as both philosophically and scientifically true in his day. Albert Einstein,[3] however, in noting the equivalence of gravitational and centripetal acceleration, concluded that the Copernican and Ptolemaic theories were equally true to observations. The Soviets,[4] on the contrary, are loud in their protestation that only the Copernican theory is true—in keeping with their opposition to apparently subjective idealism and to seemingly religious associations with the geocentric Ptolemaic theory. Such musings as I have just noted will justly be regarded as somewhat extraneous by an engineer anxiously concerned with the design of a satellite. Yet the physicist, pioneering on the frontier of science, will treat such thoughts as second nature.

The Concept of Mass

As a second example let us consider the familiar concept of mass.[3, 5] It is common to find in modern textbooks Newton's first two laws on motion stated for everyday terrestial problems without any specification of an inertial frame of reference. Approximately 90% of the college textbooks on general physics are negligent in this regard. Some more sophisticated ones, it is true, formulate

[2] Angus Armitage, *Copernicus*, George Allen & Union, London, 1938.

[3] Philipp Frank, *Philosophy of Science*, Prentice-Hall, Englewood Cliffs, 1957.

[4] Gustav A. Wetter, *Dialectical Materialism*, rev. ed., transl. P. Heath; Frederick A. Praeger, New York, 1958.

[5] R. B. Lindsay and H. Margenau, *The Foundations of Physics*, John Wiley and Sons, New York, 1936. R. J. Seeger, "On Teaching Physical Mechanics" JOURNAL, Vol. 46, p. 842 (1956).

the first law as a special case of the second one. In this instance, however, they are equally liable to fail to give a frame of reference for the acceleration. Newton's own omission was justifiable on the basis of his special assumptions of absolute space and of absolute time. Our modern relativistic point of view is quite different. What is mass? In a current text of college physics we read, "Whether we say energy has mass or is mass or appears as mass is only playing with words." If we substitute the word "pig" for energy, we then read, "Whether I say I have a pig or am a pig or look like a pig is only playing with words." No difference? So, too, the definition of mass is highly important; it involves the very relationship of mass and energy.

We begin, as you know, with the inertial experience of two bodies colliding. Noting that the ratio of their accelerations is always constant, we regard this as the ratio of two other constants, each one peculiar to the body in question and arbitrarily called its mass, as a measure of material inertia. The product of the mass of each body and the proper acceleration is then seen to be constant for a given observation. It is further observed to be always a function of distance and of the time (possibly of the velocity); as such it is termed force. Thus we may consider the mass of any body as the ratio of the force acting on it to its acceleration. If the mass of a body were always constant, however, continuously increasing the time for a given force and for constant acceleration would result in an indefinitely increasing velocity—contrary to the principle of restricted relativity. Hence we are forced to give up our notion of the constancy of mass, although we can still conceive of mass as the ratio of force to acceleration. It so happens that the observed value of this ratio depends upon whether measurements are made parallel to the direction of a body's motion or at right angles to it. If we choose the transverse measurements, we find that the principle of conservation of momentum still holds. Accordingly, we define relativistic mass on this basis. For comparatively small velocities this mass becomes approximately equal to a constant, the so-called rest-mass, plus the kinetic energy over the square of the speed of light. This rest-mass apparently inherits the characteristic of constancy, whereas the relativistic mass itself retains the defining ratio of force to acceleration. In experiments on nuclear fission, furthermore, the relativistic mass is observed to remain constant. In view of the increasing kinetic energy of the fragments, however, we are forced to conclude that the rest-mass has decreased. All in all, we find that relativistic mass inherits most of the original properties. Thus we are led to the conservation of relativistic mass and its associated principle of the conservation of energy. I would emphasize here that mass and energy are not interchangeable concepts. In any experiment the total initial mass is equal to the total final mass, and the total initial energy is equal to the total final energy. The Soviets, too, are quite insistent that energy and mass are not identical, that there is not a suggestion of transfer of mass into energy, or vice versa.

You may be interested in the Soviet concern about matter.[4] One of Vladimir Lenin's basic philosophical principles,[6] of course, is the conservation of matter, which is preserved even nowadays by the Soviets' regarding stuff and radiation as different forms of matter. The present Soviet outlook on energy, however, is quite different from what it was prior to the development of atomic energy, with its experimentally verified relation, $E = mc^2$. I doubt that the engineer in training, who is concerned primarily with the use of the concept of mass for everyday fixed frames of reference, will have much opportunity to try to understand the philosophy and ideology of atomic energy.

Quantum Mechanics

As a third example, let us consider quantum mechanics. One often hears nowadays the opinion that quantum mechanics is obscure or even irrational. There are even those who would argue dogmatically that quantum mechanics is evidence either for spiritualism or for materialism. Most of this discussion

[6] Vladimir I. Lenin, *Materialism and Empirio-Criticism*, Moscow-London, 1952.

centers about Heisenberg's uncertainty principle, viz., the fact that the position and momentum of an elementary "particle," such as an electron, cannot be simultaneously observed with increasing precision due to interference with the measurements. We apparently have these alternatives: either to be agnostic, i.e., to regard an elementary "particle" as unknowable, or to invent a strange "particle" which cannot have a definite position and a definite momentum. Thus one finds people sometimes speaking of particles with wavelike characteristics. One physics textbook warns of these "particles that have a somewhat 'unreal' existence." The answer to this dilemma was given by Niels Bohr [7] in his complementarity relation. The laws of motion for small "particles," it must be admitted, relate only observable initial conditions to observable final results. Nothing whatever can be stated with respect to the actual motion of such "particles." We are so accustomed to thinking in the everyday language of classical physics that we would like to continue so to speak and think, inasmuch as our experiments are necessarily always couched in this language. Nevertheless, we can do so only under the very limitations of language. For example, we may speak observationally of the position of an atomic "particle," but not at the same time of its momentum. We may speak experientially of the energy of such a wave, but not simultaneously of its time. Strictly speaking, we can say only that the product of the position uncertainty and of the momentum uncertainty for a "particle" is equal at least to Planck's constant h divided by 2π. The Soviets,[4] in this instance, are particularly concerned about the subjective idealism which is apparently stressed by many scientists, who would accordingly regard the world as unknown to a degree or even as unknowable to some extent. Evidently a practicing engineer will be inclined to be uncritical with respect to such metaphysical interpretations of physics.

[7] Niels Bohr, *Atomic Theory and the Description of Nature*, Macmillan, New York, 1934. *Atomic Physics and Human Knowledge*, John Wiley and Sons, New York, 1958.

A Broader Horizon

These few illustrations must suffice here to substantiate my thesis that an emphasis upon the applications of physics will probably serve as a blinder to philosophical relations. The student is thus confronted with a limited horizon for the past, for the present, and for the future. This argument is not as academic as it might appear. In his 1957 Annual Report the organic chemist Aleksander N. Nesmeyanov, President of the Soviet Academy of Sciences, stated, "Scientists in all branches of knowledge cannot and should not remain indifferent to the ideological struggle between Communism and Capitalism. . . . . One of the most important tasks of science in the light of the Communist Party of the Soviet Union is the further development of the Marxist-Lenin Theory." Some of you may have seen on May 20, 1959, the newspaper account of Professor Edward Teller's prediction that the scientific leadership of the world will be assumed by Russia within ten years and that the world itself, indeed, may become modeled after Soviet ideals within forty years. Regardless of the accuracy of these prognostications, the publicized goals of the Soviet Union certainly create a time-urgency ahead for us all, students as well as faculty. We cannot afford to have hazy notions about the possible philosophical and ideological interpretations of science.

Physics, it seems to me, affords a unique opportunity to clarify our basic scientific concepts. In this sense physics and engineering education are complementary, not supplementary. Together their interrelated patterns reveal organic growth, not merely mechanical additions. Today I am pleading primarily for engineering education to appreciate its physics complement. I do not propose to discuss now the equally important aspect of the need for engineering in physics education—if we are to survive in our present technological struggle. No matter from which direction we look—from the viewpoint of physics or from the viewpoint of engineering—physics and engineering education are complementary.

Statistical Thermodynamics

JOHN F. LEE

Broughton Professor of Mechanical Engineering
and
Head, Department of Mechanical Engineering
North Carolina State College

Introduction

The statistical-microscopic viewpoint of the behavior of matter and energy is a comparatively new one to engineers. However, the viewpoint itself is not new but is an innovation in engineering education brought about by the pressures of modern engineering for a better understanding of phenomena which cannot be observed in the laboratory. The statistical-microscopic concept comes more clearly into focus in the branch of engineering science known as statistical thermodynamics.

Statistical thermodynamics is fundamental to a clear understanding of many phenomena which are of concern to modern engineers and scientists. This viewpoint is not only essential to understanding problems in such areas as nuclear engineering, radiation, thermal and electrical conductivity, electronics, magnetic fields, combustion, gas dynamics, magnetohydrodynamics, reaction kinetics, mechanics of materials, and low-temperature phenomena, but is basic to the solution of these problems. Nevertheless, relatively few schools of engineering offer courses in statistical thermodynamics, due possibly to the fact that this area of study is ill-defined for engineers. The source literature is abundant but is often discouraging because of conceptual difficulties and abstractions which hold little fascination for engineers who, although insistent on rigor, are not primarily interested in elegance. The purpose of this paper is to suggest an outline of a course in statistical thermodynamics for undergraduate and beginning graduate students in engineering with the broadened objective of presenting basic principles of kinetic theory, quantum mechanics, statistical mechanics, fluctuations and irreversible phenomena. Such a course need not require more background than a general course in physics and the mathematical maturity normally required of engineering undergraduates.

Presented at the ASEE Annual Meeting, Pittsburgh, June 15, 1959. Recommended by the Mechanical Engineering Division.

Definitions

The definition of classical thermodynamics restricts this branch of science and engineering to general laws governing the transfer of energy between macroscopic systems, the conservation of energy, the trend toward equilibrium as deduced from the existence of entropy, and the coordinates of macroscopic systems. Classical thermodynamics is not concerned with descriptions of microscopic behavior of a system or rate processes. Classical thermodynamics embodies the generalizations derived from observation or experience and is, at once, an experimental science whose greatest virtue is its generality. The price of generality is restriction in scope. Hence, the first two laws of thermodynamics appear as somewhat dogmatic statements of fact. The so-called third law of thermodynamics is meaningless within the framework of classical thermodynamics. The absolute values of properties such as entropy and internal energy cannot be determined from classical thermodynamics.

Classical thermodynamics is a powerful philosophy which should be appreciated for its own beauty and usefulness.

Historically and pedagogically there is much merit in insisting that statistical thermodynamics be prefaced by a study of classical thermodynamics. From the standpoint of logic it would appear more satisfactory to begin with statistical thermodynamics and end with the generalizations of classical thermodynamics. Such a procedure would suggest that we begin with a study of statistical mechanics.

Statistical mechanics is a branch of physics concerned with the interpretation and evaluation of the properties of microscopic systems (electrons, ions, atoms, molecules, etc.) to enable the prediction of the properties of the macroscopic system embodying these elementary systems. Like the classical thermodynamics, statistical mechanics is concerned only with equilibrium properties. Statistical mechanics applies the laws of mechanics (at least in imagination) to the microscopic systems. Statistical methods are employed because of the utter impossibility of solving the equations of mechanics for each of the millions of microscopic systems comprising a macroscopic system. Consequently, statistical mechanics is concerned with average behavior. In an analogous sense, a life insurance firm works with actuarial data derived from population-statistics.

Of course, statistical mechanics must be based on some concept of mechanics. If it is assumed that Newtonian or classical mechanics, which is derived from the observation of macroscopic systems, also can be applied to microscopic systems, the statistical mechanics is said to be classical. The classical statistical mechanics (usually referred to simply as the classical statistics) originated in the theories of Maxwell, Boltzmann, Gibbs, Fowler and some others. However, it has been observed that the classical mechanics fails when applied to systems of a size smaller than h^3 (where h is Planck's constant) and in these situations the newer quantum mechanics must be used. When statistical methods are applied to quantum mechanics the result is quantum statistical mechanics or, more simply, quantum statistics. The quantum statistics originated in the theories of Einstein, Fermi, Dirac and Bose. Furthermore, the coordinates of mechanical systems are expressed in terms of force-space-time concepts (mass, position, momentum, velocity, etc.) and the coordinates of thermodynamic systems are expressed in terms of temperature, internal energy, entropy, specific heat capacity, etc. Therefore, some entirely new ideas are needed to bridge this gap and these ideas are provided by the classical and quantum statistics. The local fluctuations from the average behavior predicted by the statistics are also properly a part of statistical mechanics.

Rate processes which give the velocity with which equilibrium is reached are the primary concern of kinetic theory. The molecular theory of gases is well developed and hence the kinetic theory of gases presents a fruitful approach to rate processes. The kinetic theories of the solid and liquid phases are not so well developed but are the subject of widespread investigation at the present time. Kinetic theory deals with transport phenomena such as viscosity, diffusion, thermal conductivity and electrical mobility.

Statistical Thermodynamics for Engineers

Historically, classical thermodynamics predates the classical statistical mechanics, which in turn predates the quantum statistical mechanics. The classical statistics represents a limiting case of the more general quantum statistics. If the historical order had been reversed it would have been possible to derive all the conclusions of classical thermodynamics from statistical mechanics alone. However, classical thermodynamics can be viewed as a logical outgrowth of statistical mechanics, and if the link between the coordinates of statistical mechanics and the classical thermodynamics is established, the combined sciences constitute what is called statistical thermodynamics. Statistical thermodynamics then provides an elegant and satisfactory justification of the laws of thermodynamics as well as a means of computing the absolute values of thermodynamic coordinates.

Engineering statistical thermodynamics is an engineering science; i.e., it provides

a firm basis of knowledge and a mode of scientific reasoning fundamental to the understanding of other engineering sciences and to enginering applications. An engineering science is not primarily concerned with its direct application, and yet it cannot be said that it is preoccupied with elegance, extreme rigor, historical order or completeness. It is only by adopting this viewpoint that a self-contained course in statistical thermodynamics can be attempted for enginers, many of whom may not be conversant with the details of quantum theory, quantum mechanics, spectroscopy and the specialized mathematics needed for a complete, elegant and completely rigorous treatment of the subject.

Like the Constitution of the United States, the definition of scope of an engineering science should not be inflexible. Therefore, kinetic theory, transport phenomena, fluctuations and non-equilibrium thermodynamics, although not usually considered to be within the scope of statistical thermodynamics, should be included in engineering statistical thermodynamics for pedagogical reasons and to broaden the usefulness of the study for engineers.

The Pedagogy of Engineering Statistical Thermodynamics

The most logical arrangement of subject matter in a course is not always the most successful procedure from the standpoint of pedagogy. In the first place, it appears absolutely desirable to teach classical thermodynamics as a separate entity because of the power of its generality. Experience has shown that if the historical order is followed (that is, statistical thermodynamics is preceded by a study of classical thermodynamics), the student approaches the study of statistical thermodynamics with a superior potential for understanding. This order provides a general viewpoint from which the myriad pieces of the microscopic approach can be seen to fall into a logical pattern.

Once the study of statistical thermodynamics is begun, the first serious obstacle to overcome is the predilection of engineers for physical models. To be successful, the teacher must utilize all of his persuasiveness to wean the student from this tendency. One eminently successful technique is to begin with the kinetic theory of an ideal gas. The student is familiar with this model and the study serves very well to confirm familiar facts and to disabuse some misconceptions. It also demonstrates the utility of a simplified, if unreal, model as an introductory device for the scientific analysis of more complex models.

With the simple model of an ideal gas, the concept of the distribution of the molecules as points in velocity space can be established. This is a first step in preparing the student for the shock of $6N$-dimensional hyperspace (where N is the number of identical and independent particles) known as phase space, at which point a physical model is impossible. Once the concept of phase space is understood, nothing more difficult than the combinatory and probability theorems, the Stirling approximation and the use of Lagrangian multipliers is involved in the development of the classical statistics. At this point the $6N$ dimensions of phase space are linked to the thermodynamic coordinates by means of the partition function.

The next conceptual difficulty arises in connection with the quantum theory, which is an essential step in the development of the quantum statistics. Here a more detailed description of the model is needed and the insistence on a physical model can prove entirely frustrating. At this point it is helpful to begin with the simple Bohr model of the atom and by gradual degrees of sophistication force the student to accept an abstract model. He is then ready to understand the uncertainty principle and can accept wave-particle duality as an abstract mathematical model which may or may not conform to physical reality. This, of course, is fairly sophisticated empiricism whose only justification for its acceptance rests entirely on the fact that it works.

The final step is the computation of partition functions for systems of independent and dependent particles and the bridge to classical thermodynamics is established. Interesting dividends include

the establishment from theory of such empirical laws as the law of mass action, chemical equilibrium, diffusion and the Onsager reciprocal relations. Many other interesting topics such as negative absolute temperature, negative absolute pressure and the so-called third law are open to full and intelligent discussion.

Usefulness of Statistical Thermodynamics

One important factor which differentiates engineers from other scientists is the motivation to satisfy a recognized human need as the *raison d'etre* of his profession. This motivation must be kept constantly before engineering students, and in a comparatively new course, such as statistical thermodynamics, it is essential. One way to accomplish this end is through the assigned problems, which can include the computation of practical entropies and internal energies for comparison with tabulated values. The computation of thermal conductivities under conditions which are not possible in the laboratory is another good example of the usefulness of the subject. General equations for determining the absolute properties of various substances can be set up for computation on high-speed electronic computers. Finally, it can be shown that more accurate values can be obtained at far less cost by computation than by experiment. However, the student should be kept constantly aware of the fact that statistical thermodynamics is a comparatively young science and must undergo tremendous development before its full potentialities as an engineering tool can be realized.

Suggested Syllabus for a Course in Engineering Statistical Thermodynamics

1. INTRODUCTION
   - a. Statistical thermodynamics
   - b. Engineering statistical thermodynamics
   - c. Review of thermodynamic relationships
   - d. Review of combinatory and probability theorems
   - e. Symbols and units
2. KINETIC THEORY OF AN IDEAL GAS
   - a. Molecular model
   - b. Collisions with a stationary wall
   - c. Pressure of a gas
   - d. Absolute temperature
   - e. Collisions with a moving wall
   - f. The Clausius equation of state
   - g. The van der Waals equation of state
3. THE DISTRIBUTION OF MOLECULAR VELOCITIES
   - a. The distribution of molecular velocities
   - b. Evaluation of distribution constants
   - c. The error function
   - d. The energy distribution function
   - e. Molecular beams
   - f. Experimental verification of Maxwell velocity distribution
   - g. The principle of equipartition of energy
   - h. Classical theory of specific heats
   - i. Specific heats of a solid
4. TRANSPORT PHENOMENA
   - a. Mean free path
   - b. The distribution of free paths
   - c. Coefficient of viscosity
   - d. Thermal conductivity
   - e. Coefficient of diffusion
5. THE MAXWELL-BOLTZMAN STATISTICS
   - a. Phase space
   - b. Microstates and macrostates
   - c. Thermodynamic probability
   - d. Entropy and probability
   - e. Monatomic ideal gas
   - f. Barometric equation
   - g. The principle of equipartition of energy
   - h. Theory of paramagnetism
6. QUANTUM MECHANICS
   - a. Introduction
   - b. The quantum theory of radiation
   - c. The atomic model
   - d. The Heisenberg uncertainty principle
   - e. The de Broglie principle
   - f. The Schrodinger equation
   - g. Interpretation of the Schrodinger equation
   - h. Statistical weight and the harmonic oscillator
7. QUANTUM STATISTICS
   - a. Difficulties with the Maxwell-Boltzmann statistics

b. The Bose-Einstein statistics
c. The Maxwell-Boltzmann statistics
d. Statistics of a photon gas
e. The Fermi-Dirac statistics
f. Velocity, speed, and energy distribution functions
g. Specific heat of an electron gas
h. Thermionic emission

8. PARTITION FUNCTIONS

a. Introduction
b. The partition function
c. Translational partition function
d. Rotational partition function
e. Vibrational partition function
f. Electronic partition function
g. Nuclear partition function

9. PARTITION FUNCTIONS AND THERMODYNAMIC COORDINATES

a. Introduction
b. Internal energy
c. Entropy
d. Helmholtz function
e. Pressure and Gibbs function
f. Enthalpy
g. Work and heat
h. Properties of ideal gases
i. Translational entropy of an ideal gas
j. Vibrational, rotational, electronic and nuclear contributions to thermodynamic properties
k. Thermodynamic properties of polyatomic ideal gases

10. SPECIFIC HEATS OF GASES

a. Introduction
b. Specific heat of diatomic gases
c. Fine corrections for a diatomic gas
d. Ortho- and para-hydrogen
e. Polyatomic gases
f. Gas mixtures

11. COMPRESSED GASES AND LIQUIDS

a. Introduction
b. Non-ideal gases
c. Equation of state of non-ideal gases
d. Compressed gases
e. The critical state
f. Liquid-vapor equilibrium
g. Liquid phase

12. THE SOLID PHASE

a. Introduction
b. Einstein specific heat of solids
c. Debye theory of specific heats
d. Thermodynamic properties of solids
e. Equation of state of solids
f. Order and disorder in solids
g. The melting point

13. CHEMICAL SYSTEMS

a. Introduction
b. Law of mass action
c. Chemical equilibrium
d. Dissociation
e. Equilibrium constants
f. Computation of equilibrium constants
g. Third law of thermodynamics

14. FLUCTUATIONS

a. Density fluctuations in a gas
b. Theory of Brownian motion
c. Brownian motion of a galvanometer
d. The small-shot effect
e. Johnson noise

15. IRREVERSIBLE PROCESSES

a. Introduction
b. Entropy production
c. Coupled phenomena
d. Onsager's reciprocal relations
e. Proof of Onsager's reciprocal relations
f. Coupled phenomena
g. Thermoelectric phenomena
h. Thermomechanical phenomena

NOW AVAILABLE

Attractive Lapel Buttons and Pins

displaying

The ASEE Emblem

Blue Enamel on Gold with White Enamel Letters

$3.00

Office of the Secretary, University of Illinois, Urbana, Illinois

Sponsored Research—Good or Bad?

RALPH A. MORGEN

President, Rose Polytechnic Institute, Terre Haute, Indiana
Formerly Research Director, Purdue Research Foundation

Research is an essential activity for any department of an engineering school. Without research, the department becomes stagnant and pedantic. Research costs money. Therefore, funds must be obtained in order to conduct the research. Poor research should not be done and thus no funds should be supplied for it. Good research should be done and funds must be supplied for it regardless of source.

Now let us see how we arrive at these conclusions. Naturally, we must start with some premises.

Premise number one is that the essential purpose of institutions of higher learning is education. Anything which is done to detract from the major purpose of the institution of higher learning is dangerous and cannot be tolerated if the institution is to make its maximum contribution to education.

For example, the amount of emphasis on athletics must bear a direct relationship to its effect on the education of the students. An appropriate emphasis, which allows the normal animal spirits of the young men and women to be dissipated without affecting their educational objectives, is the amount to be striven for.

While research does not bear quite the same relationship to the attainment of the objectives of higher education as athletics does, an analogy can be drawn. An institution of higher learning, in general, does research for three major reasons. Traditionally, the universities have been the source of new knowledge and the mechanism by which the frontiers of knowledge are expanded. Thus this objective is the traditional primary reason for research at an institution of higher learning.

The second and almost equally important reason is that staff which spends its time wholly on repetitive undergraduate teaching soon becomes stale and tends to fall behind the parade of events. This is particularly true now in the fields of science and engineering.

The third and, today, the paramount reason for research in institutions of higher learning is that it serves as a mechanism for teaching students to think independently and to attack problems on their own when they are no longer under the supervision of the staff of an educational institution. For graduate students, understanding the techniques of good research is essential as part of their learning process. For undergraduate students, the feedback from the research in progress at the institution is essential as a demonstration that science and engineering are dynamic, growing areas and that the frontiers can and must expand continually.

If this basic premise and the three major outgrowths from this premise are accepted, then the conclusion must be reached that research is essential for any institution of higher learning to fulfill its major objective, the education of students.

Amount of Research

Premise number two concerns the amount of research which should be done in order that any particular institution can accomplish its mission in terms of its own circumstances. In engineering, institutions fall roughly into three classifications: (a) those which offer education only to the level of the bachelor's degree, (b) those which offer education

Presented before Chemical Engineering Division, American Society for Engineering Education, June 16, 1959, Pittsburgh, Pennsylvania.

to the level of the master's degree, and (c) those which offer education to the level of the doctor's degree. Parenthetically, where the word *institution* is used here, the word *department* might be substituted, because within a particular institution different departments might offer work to different levels. Therefore, the reasoning which follows can apply to specific departments as well as to the institution as a whole.

In the original premise, the point was made that research is important to the staff and as feedback to the undergraduate students regardless of whether or not advanced degrees are given at the institution. Obviously, however, an institution which does not offer work beyond the bachelor's degree should not have as extensive a research program nor should it be spending as much money on its research program as one which has a large graduate program.

A Rule of Thumb

Over the years I have developed a "rule of thumb" for determining the dollar value of research which various institutions might do, and I have tried to equate that dollar value to the accomplishments of the institution as might be judged by a group that would investigate the institution for accrediting purposes. I have found the "rule of thumb" very effective and, within limits, a reasonably good quantitative measure.

If the budget of the department can be analyzed and all those things which are considered the "teaching functions" put in one category and all those things which are considered the "research functions" placed in another category, a reasonable relationship can be achieved. This relationship, of course, can vary depending on who the individual is and on who is analyzing the budget. In addition, the argument can soundly be advanced that "research" is, in effect, "teaching" and that, therefore, there is no distinction between the two. If these two objections can be overlooked, however, the "rule of thumb" still proves to be a useful device for analysis. Here it is:

For those institutions or departments which offer only engineering or science work to the bachelor's degree level, approximately 25 cents should be spent on research functions for each dollar spent on the teaching functions. What the accuracy of this figure is I am not at all sure. But it can be said with reasonable assurance that when the research figure falls to 10% or less in institutions of this type, there are usually found serious deficiencies in the teaching functions and in the curricula. When, on the other hand, this figure goes much above 50% it is usually found that the research is of a character whose value to an institution of higher learning can be seriously questioned.

For those institutions of higher learning or departments which offer the master's degree, the equivalent figure should be about 50% budgeted for research expenditures as compared to the teaching expenditures in the department. Schools or departments which allow the research figure to fall to 25% or less of the teaching budget will usually be found to have serious deficiencies in the undergraduate curriculum, while those who are getting towards the 75 to 100% ratio of research to teaching should be approaching the point where the doctorate can be offered in that particular department providing, of course, that the research is of the appropriate caliber.

Finally, those departments or institutions which are offering the doctorate should be spending about as much for the support of the research program as for the teaching function. If, however, that figure falls as low as 50% of the teaching budget, a very weak doctorate program is indicated. The undergraduate curriculum, however, usually remains above the minimum for accreditation purposes.

On the other hand, when the research budget gets to be 200% or more of the teaching budget there develops another danger which must be carefully watched by the staff. In this case there is a tendency to overemphasize the graduate and research program as compared to the undergraduate program. In some cases this tendency has caused large research

"institutes" to be incorporated erroneously into the budget of the educational institution. Fortunately, there is a strong movement at the present time to separate these large "research centers," and not confuse them with the true academic budget for teaching and research. The National Science Foundation is reporting its figures this way now and this helps to clarify the matter. For example, The Jet Propulsion Laboratory is no longer considered a part of the academic program of the California Institute of Technology, nor are the Lincoln Laboratories still so considered by the Massachusetts Institute of Technology nor Argonne National Laboratories by the University of Chicago. The reader is referred to the "list of research centers" as published by the National Science Foundation for an explanation of this difference.

Sources of Funds

Now, having agreed first, that research is essential for an institution of higher learning and second, that the amount of research varies with the educational objectives of that institution, the next and final question is, where do the funds come from to conduct the amount of research which the institution of higher learning should be doing in accordance with its objectives?

In my observation, no institution of higher learning either in the United States or in three foreign countries which I have had the chance to observe in the past year, namely, France, Holland and Russia, obtains enough money from its "regular" sources of income to support its research program in accordance with the "rule of thumb" which I have announced above. In the United States this statement applies to both tax-supported institutions and privately supported institutions.

The research support, therefore, must come from gifts, grants, contracts and other sources specifically designated for this particular purpose. In France and in Holland the individual professor negotiates with individual industries, the ministry of defense, and other ministries for individual research contracts in areas of interest to himself. The institutions of higher learning make little attempt to administer or make general rules regarding contracts, and therefore, the quality of the research is the sole responsibility of the professor who negotiates the contract or obtains the grant. However, the professor includes in his contract or grant a payment to the institution for the use of facilities and laboratories in certain cases.

In Russia, the responsibility of negotiating the contracts and research grants is that of the institution in cooperation with the professor. The contracts are made with such agencies as industries and academies of science.

In our country the pattern is quite diffuse. The study made by ASEE's Engineering College Research Council, under a grant from the National Science Foundation, entitled "Survey of Research Capabilities," indicates that the trend in this country is rapidly becoming one of central negotiation of research grants and contracts by one agency of the institution of higher learning. The professor is the controlling factor on the type and subject matter of the research, but the quality, kind and amount of research which will be acceptable to the institution are functions of a central research agency.

The trend today appears to be to encourage the staffs of the institutions of higher learning to engage in research of the kind that could be called expansion of the frontiers of knowledge and to discourage the trend of research that would be classified as application to a particular device, machine or operation. The belief is that the latter type of research is the kind which should be done by the nonprofit research corporations not allied to universities, and by the industrial laboratories.

There appears to be no relationship between the source of the funds and the kind of research which is done. The relationship appears to be between the source of funds and the policy of the institution of higher learning and staff of that institution on what kind of research they are willing to do and desirous of doing. The only connection which appears at all valid is that research of the

kind which an educational institution should be doing seldom can be accomplished in one year. The contracts, grants or other methods of supporting that research, therefore, should be of longer duration than one year. This trend is quite evident on the American scene. Practically all government agencies, while they may be required in certain cases to contract year by year, guarantee to the professor and the institution that the research will be brought to an orderly conclusion without abrupt cessation of funds even if the research is not completed in the originally specified contract period. In most of the cases that this observer has checked, when research contracts at universities are abruptly cancelled because of vagaries and changes of governmental policy, there is some question as to whether or not the university should have been engaged in that particular research in the first place. Again, this is not a 100% correct conclusion but the trend is certainly in that direction.

Thus we have now come almost full cycle and have built up a case for our conclusions as stated in the opening statements as follows: Research is an essential activity for any department of an engineering school. Without research, the department becomes stagnant and pedantic. Research costs money. Therefore, funds must be obtained in order to conduct the research. Research which is not appropriate for a university should not be done regardless of the availability of funds. On the other hand, good academic research should be done and funds must be supplied for it regardless of source.

NSF SCIENCE FACULTY AND SENIOR POSTDOCTORAL FELLOWSHIPS

The National Science Foundation has announced the award of 285 Science Faculty Fellowships in the sciences for the fiscal year 1960, of which, 86 were in engineering. These fellowships are offered as a means of improving the teaching of science, mathematics and engineering in American colleges and universities. The primary purpose of these awards is to provide an opportunity for college and university science teachers to enhance their effectiveness as teachers.

Eligibility requirements include a baccalaureate degree or its equivalent, demonstrated ability and special aptitude for science teaching and advanced training, and three years of full-time science teaching at the college level.

Science Faculty Fellowship awardees were selected from 762 applicants from all parts of the United States and its territories on the basis of ability as indicated by letters of recommendation, academic and professional records, and other evidence of attainment and promise. Selection of awardees was made by the National Science Foundation.

The Foundation also announced the award of 75 Senior Postdoctoral Fellowships in the sciences for the fiscal year 1960, selected from 259 applicants. Five of these were in engineering.

Senior Postdoctoral Fellowships were awarded to scientists of demonstrated ability and special aptitude for productive scholarship in the sciences. Selection of awardees was made by the National Science Foundation.

Science Faculty and Senior Postdoctoral Fellows receive stipends adjusted to approximate their salaried incomes and an allowance to aid in defraying the cost of travel to the fellowship institution. These fellowships are awarded for study and/or research at an appropriate nonprofit American or nonprofit foreign institution.

The National Science Foundation expects to reopen the Science Faculty and Senior Postdoctoral Fellowship Programs in May for awards to be made in December, 1960.

Faculty Compensation for Sponsored Research: Good or Bad?

W. A. KOEHLER

Director, Engineering Experiment Station
and Acting Dean, The Graduate School
West Virginia University
Morgantown, West Virginia

There has been an increasing participation by educational institutions in government-sponsored and industry-sponsored research projects, and policies by the educational institutions regarding sponsored research projects have been varied, with no general common plan showing any signs of being evolved. There are especially wide divergencies in policies as regards extra compensation for academic staff members who direct or conduct sponsored research. It is with this subject that this paper is concerned.

There is little disagreement now among engineering educators about the value and soundness of sponsored research conducted in educational institutions. It is agreed, however, that sponsored research can become a nuisance if ill-advised policies are allowed to exist, or if the work is allowed to get out of hand, or if no policies exist at all.

One of the points of disagreement among various school administrators is whether or not academic faculty members should receive extra compensation for directing or conducting sponsored research. On the other hand, there seems to be little disagreement as to whether faculty members should be permitted to do consulting work for extra compensation.

In the Neilly report [1] to the question, "Does your institution permit academic staff members to do consulting work for compensation in addition to their institutional salaries?", out of 98 answers 95 reported "yes," none "no." But to the question, "Does your institution permit academic staff members to do sponsored research work for compensation in addition to their institutional salaries?", out of 95 answers only 63 answered "yes" and 23 answered "no," and there were many qualifying statements among the "yes" answers.

In discussing variations in research policies [2] an engineering administrator states that, as an institutional policy, "Faculty members serving as directors of or assigned to participate in sponsored research . . . shall not by virtue of such arrangement receive an extra stipend." Later in the same discussion, the same administrator states, "Academic faculty, including Research Fellows, are permitted an average of one day a week throughout the year for consulting work. There is no formal supervision of consulting practice in terms of either days worked or dollars earned." Another engineering administrator states in the same discussion, ". . . no additional compensation is authorized for participation in special contracts or special teaching assignments," but also, "Both teaching and research faculty members are permitted to do consulting work. . . ."

It is evident that many educational engineering administrators frown upon, or their institutional policies prohibit, academic faculty members' receiving addi-

[1] Neilly, V. E., "Remuneration Policies of Engineering Colleges in Regard to Research and Consulting," JOURNAL, Vol. 45, pp. 449–453 (1955).

[2] Barlow, H. W., editor, Kurt F. Wendt, J. H. Mulligan, and F. C. Lindvall, "Logical Variations in the Research Policies of Educational Institutions," JOURNAL, Vol. 47, pp. 798–809 (1957).

Presented to the Chemical Engineering Division at the ASEE Annual Meeting in Pittsburgh, June, 1959.

tional compensation for directing or conducting sponsored research (the funds in all cases to be supplied by the sponsor) but fully endorse compensation for consulting work by the faculty.

Reasons for these apparently inconsistent policies are seldom given in the literature; the statements are usually of a categorical nature. It is generally agreed that both sponsored research and consulting work are means for professional development. In favor of sponsored research over consulting work may be listed:

1. Sponsored research is nearly always done on the campus. Faculty members working on the project are available for conferences or consultation by students and other faculty members if sudden need arises.

2. The work can be integrated with the academic program with the least conflict or even with beneficial cooperation, whereas for consulting work the faculty member may be called away from the campus on short notice to the client's plant as emergencies may arise. Such emergencies may require a longer stay than anticipated. Surely there are many telegrams or telephone calls received by heads of departments to the effect, "I just can't be back tomorrow, ask Jim to take care of my classes," or morning telegrams, "Plane grounded, will not be back until evening."

3. Since sponsored research is done on the campus, it is easier to supervise administratively than is consulting work, so that abuses can be avoided.

4. Consulting work may involve long hours of travel, sometimes requiring starts early in the morning or travel late into the night. This can take up considerable time and energy on the part of the faculty member doing consulting work, a factor which is not encountered in sponsored research work.

5. Sponsored research work brings in additional funds, or the equivalent, to the institution in the form of equipment, supplies and especially as an overhead charged against the project.

6. The ability to pay extra compensation to academic staff members for doing sponsored research makes it possible for administrations to hold and attract capable teachers. Some men are not suited for or interested in consulting work but are good research workers, or the school may be situated remote from industrial centers so that consulting work is not practical. Compensated sponsored research work is a good solution to the problem of adequate remuneration for staff members in such cases.

7. Consulting work is very commonly of a confidential nature so that it cannot lead to publication of technical papers, some of the most valuable publicity an educational institution can obtain. In sponsored research the contract or agreement usually has a statement giving the institution publication rights.

8. Sponsored research lends itself better to integration with the academic program. Quite commonly graduate students use the sponsored project or a special phase of it for their master's or doctor's theses.

It is admitted that some of the points made above apply more to the schools somewhat removed from the industrial centers, but they can and do have application to schools in all areas.

The question then arises, why should the academic staff members working on sponsored research not receive additional compensation for their work as well as those doing consulting work? Several years ago, in connection with a study made at West Virginia University in regard to this subject, I wrote to the deans of twelve colleges of engineering soliciting their comments on the subject of additional compensation for faculty doing sponsored research work. The majority of replies indicated opposition to additional compensation. In very direct or in more veiled statements the opposition was almost entirely due to feared "headaches" such a policy might cause the administration. In the published literature these comments may be summed up by the statement, "It must be obvious that an immense amount of inter-departmental heart-burning and jealousy is avoided by this 'no-extra-pay' rule."[3]

[3] Parmenter, Richard, "Sponsored Research in a Large University," JOURNAL, Vol. 44, pp. 248–252 (1953).

Why this should be true for compensated sponsored research any more than for compensated consulting work is not clear to your speaker. Most schools have rules or general policies that apply to sponsored research and consulting work alike. These include a policy, for example, that no faculty member is directed or importuned to undertake sponsored research or to do consulting work; *he* initiates the move. Why, then, should there be jealousy, strife or friction in one case more than in the other?

However, it seems that in a well administered and managed educational institution there should be little difficulty in regard to jealousy and strife. In a number of schools where extra compensation for sponsored research is permitted the system works smoothly and the "headaches" feared by some have not materialized.

In the field of engineering technology, faculty compensation for sponsored research is a stimulus to creative academic work. Without such a stimulus, engineering research and graduate programs are apt to suffer.

Supplementary References

Longenecker, Herbert E., "University Faculty Compensation Policies and Practices in the United States," University of Illinois Press, Urbana, Illinois, 1956.

Martin, Ross, J., "Faculty Compensation Policies and Practices," JOURNAL, Vol. 48, pp. 509–513 (1958).

Middlebrook, W. T., "Some Administrative Problems in Contract Research," Association of Governing Boards of State Universities and Allied Institutions, *Proceedings*, 1953, pp. 64–70.

Morgen, Ralph A., "The Role of Sponsored Research in Training Research Personnel," JOURNAL, Vol. 43, pp. 145–148 (1952).

Report No. 102, "Professional Income of Engineers, 1956," prepared by the Special Surveys Committee of Engineers Joint Council.

"Sponsored Research Policy of Colleges and Universities," American Council on Education Committee on Institutional Research Policy, American Council on Education, 1954.

Walker, Eric A., "A Suggested Research Policy for the Guidance of Engineering Schools," JOURNAL, Vol. 45, pp. 171–172 (1954).

CLASSROOM DESIGN STUDY

Four years of study of ways to improve teaching effectivesness and reduce costs on the college level have led to a $50,000 Ford Foundation grant to Rensselaer Polytechnic Institute in Troy, N. Y., for an investigation of designs of "auditorium-studio classroom facilities for the effective teaching of concepts in engineering education."

The grant to Rensselaer's School of Architecture will be used primarily to explore and develop "design prototypes for auditorium-studio facilities suitable both for the teaching of larger classes and for the production of specialized instructional materials in engineering education."

The grant, announced by Rensselaer, was made through Educational Facilities Laboratories, of the Ford Foundation. Rensselaer will be joined in the studies by Stanford and Southern Methodist universities and by Case Institute of Technology and Georgia Institute of Technology.

Dean Harold Hauf, of Rensselaer's School of Architecture, will coordinate the studies as head of a committee representing the five colleges.

Rensselaer's faculty for the last four years has been studying ways to improve teaching effectiveness, to teach larger classes, and to reduce educational costs. Coordinating the results of these studies, and set up to provide a variety of teaching aid materials and information at the request of faculty members, has been an office known as Project Reward.

Working with the Rensselaer faculty, the Project Reward office has published the results of class-size experiments which reveal that with the use of television, films, slides, revised courses and new laboratory equipment, among other things, the accomplishment of students in large classes compares favorably with that of students in smaller classes taught in the traditional manner.

Chow Line or Cafeteria

GLENN J. CHRISTENSEN

Dean of the College of Arts and Science and Director of the Curriculum in Arts-Engineering, Lehigh University, Bethlehem, Pennsylvania

The principle that a substantial portion of the hours in any engineering curriculum should be given to the humanities and social sciences is now well established by and within ASEE. There is also general agreement that this portion should approximate 20%, although some institutions provide for a higher percentage and some curricula fall short of the goal.

The point of current issue among engineering educators is whether the humanistic-social portion shall be largely prescriptive and closely integrated, or whether it should be flexible so that at least a part of the humanistic-social hours can be fitted to the interests and special abilities of the students. The 1956 report, *General Education in Engineering*, strongly advances the integrationist-prescriptive position, but it has not silenced those who hold the "anti-100%-complete-integrationist point of view."

In fact, discussion grows very spirited at times, and one is reminded of the cartoon which showed a group of earnest professional educators seated around a conference table with the conference leader saying forcefully, "Let's integrate the hell out of them."

I have always resisted having the hell integrated out of me. And I decline to arrogate to myself the authority to integrate the hell out of anyone else. Especially students.

Before I appear to magnify too greatly the differences between the two positions which are to be presented here, let me make clear an important point of agreement. We all want to make the most effective use possible of the hours available to us for the education of engineering students in the humanities and the social sciences. The crucial question is, how can these hours be used most effectively.

The official position is that these hours should provide "a designed sequence of courses extending throughout the four undergraduate years." (*General Education in Engineering*, 1956, p. viii, quoting the Hammond Report.) The 1956 Report emphasized this idea in its phrase, "the vertical sequence" (p. ix).

Now the integration of courses in a designed sequence does make for efficiency in moving toward a pre-determined end. But the danger in this, as in all self-conscious planning, is that the plan which should be the means to an end may become the end in itself. The original end may even be lost sight of.

There is the seed of this danger in the 1956 Report. I find it in point three under "Arrangements": "Elective work must be carefully controlled to assure that it *serves the purposes of the planned sequence*." (p. viii. Italics mine.) But what of the purposes of the student?

Here, I suggest, the 1956 Report not only accepts the means as an end, it turns its back on the very essence of liberal education, that it be education of the individual free man.

Now 20% of the hours in an engineering curriculum may seem like a large block to the engineering curriculum director who is squeezed by his awareness of all the mathematics, science, and engineering which should, he earnestly believes, be crowded into his curriculum. But 20% is, after all, only about 24 to 30 hours, a scant one year's work, and a very short time to gain a substantial introduction to the arts appropriate to a free man.

Presented at Summer School conducted by the Division of the Humanities and the Social Sciences and the English Division of ASEE, Pittsburgh, June 19, 1959.

Obviously, no individual can gain a liberal education in one year; so we are back to the crucial question: how can these 24 to 30 hours best be used?

A planned vertical sequence with carefully controlled electives can expose a student to a fairly large, standardized chunk of interrelated social sciences and humanities. Like the army chow line, it offers a diet rich in calories (classical), vitamins (virtuous if not virile), and minerals (man-making variety). But what an unappetizing, impersonal thing a chow line is, especially for the individual whose individuality is highly enough developed that he has a deep hunger for foods necessary for his full and normal growth although no dietitian would think of including them in an institutional mass-feeding operation.

Psychologists tell us that white rats and children, if given free choice, will over a period of time, select the foods which constitute a balanced diet for them individually. I like to think that students intelligent enough to become successful engineers, or scientists, or scholars, are as smart academically as rats and children are physically.

Returning to points of agreement, we can agree, I think, that a substantial portion of the general-education hours in the curricula of any engineering school should be common to all students at that school. These are the meat and potato parts of the humanistic-social diet—freshman English, the development of western civilization, and so forth. They are inevitable, apparently, and indispensable. They are also chock full of academic calories, and, potentially at least, are interesting.

But for the rest, I prefer a cafeteria to a chow line. I suggest an alternative reading for "Arrangement" number 3 of the 1956 Report. The original, you recall, reads thus: "Elective work must be carefully controlled to assure that it serves the purposes of the planned sequence." My alternative reads: "Elective work must be carefully selected so that the student gains the maximum individual benefit from his institution's full resources in the humanities and the social sciences."

I know, and I am sure that many of you know also, superior students who want to be engineers, who would make good engineers once they got into the practice of the profession, but who drop out of engineering education because they cannot endure four years of rigidly organized, and to that extent depersonalized, engineering education. But engineering need not lose them, and the country cannot afford to lose them. And those of us responsible for the planning of the humanistic-social portion of engineering education do that education, our own disciplines, and the country—as well as the student— a dis-service when we increase the rigidity of engineering curricula. We are also false, I feel, to the noble liberal arts tradition when we attempt to present by authoritarian prescription the arts appropriate to the free man. We may present large, well-organized portions of the corpus by prescription, but we can never represent the spirit by prescription.

Why should not an engineering student use some of his general-education hours to exploit the opportunities his college offers to study, under a dedicated and qualified teacher, any humanistic or social science subject that interests him, whether it be public speaking, Sanskrit, the symphony, anthropology, or seventeenth-century metaphysical poetry? Will he be a poorer engineer for it? I am convinced that, if he has chosen the course out of personal interest, he will ultimately be a better engineer for it.

Why should not an engineering student have the right to spend three or six semester hours opening an intellectual door just because he wants to know what is behind it? The student who is willing to gamble a portion of his instructional time on the proposition that sustained curiosity can be profitable is a good student to gamble on.

Let's not integrate the hell out of them. Let's give them a few chances to feel intellectual freedom as well as to read about it. Let's give them the freedom even to make a few mistakes—mistakes by our standards. Twenty years from now the mistakes may well prove not to have been mistakes at all.

Part-Time Graduate Study in the New York Metropolitan Area

ANTHONY B. GIORDANO

Associate Dean of the Graduate School
Polytechnic Institute of Brooklyn

The New York Metropolitan Area

Within a circle of 25 miles from Times Square, there exists a vast concentration of research, development, and advanced education in electrical engineering. The physical extent of the area under discussion is illustrated in Figure 1. Among its many interesting statistics is the fact that close to 15% of the combined membership of the American Institute of Electrical Engineers and the Institute of Radio Engineers is scattered within the confines of the broken circle—attesting to the professional vitality present here. Furthermore, both the AIEE and the IRE were founded in New York City, the former in 1884 and the latter in 1912—following the development of electrical power and light, and radio in this country.

Historically, therefore, the New York metropolitan area has contributed significantly to the evolution of electrical engineering as a science and as an industry. The evolution began at the outset of the Twentieth Century, has continued unabated to the present day level, and has already set its sights toward a boundless future. From the early days to the present, the growth of electrical enterprises in the New York area has been quite phenomenal—from the beginnings of the electric dynamo to modern space technology with its intricate telecommunication and control systems. The growth has become so intense that many firms have found it necessary to relocate in suburban areas. Centers of strong efforts have therefore gravitated near Mineola on Long Island and near White Plains in Westchester, with similar centers spread out in northern New Jersey. The resulting shift in professional population has created marked changes in the concept of advanced education in electrical engineering—as will be explained.

Presented at the Annual Meeting of ASEE in Pittsburgh, June, 1959.

Evening Graduate Programs

Evening graduate programs in the New York metropolitan area began in the 1920's. This is not surprising since the engineer employed in industry looked to graduate study as the medium for keeping abreast with modern advances and for gaining basic scientific knowledge essential for contributing to his professional endeavors. Thus, paralleling the industrial growth within the New York area, evening graduate programs developed naturally in those colleges which were easily accessible by subways, busses and automobiles. A geographical distribution of these schools is shown in Figure 1. A factual listing is given in Table 1.

Prior to 1940, evening graduate programs leading to the master's degree in electrical engineering were available at four schools. The Polytechnic Institute of Brooklyn was apparently first. Its degree program was initiated in 1928. The Polytechnic degree program was followed by similar endeavors at Stevens Institute of Technology in 1930, at Rutgers in 1932, and at New York University in 1938. They covered an extensive geographical area as already shown in Figure 1. However, to sustain the tremendous advancements which prevailed in electrical research and technology, these schools not only grew in scope through the years, but also attracted the attention of other institutions. Consequently

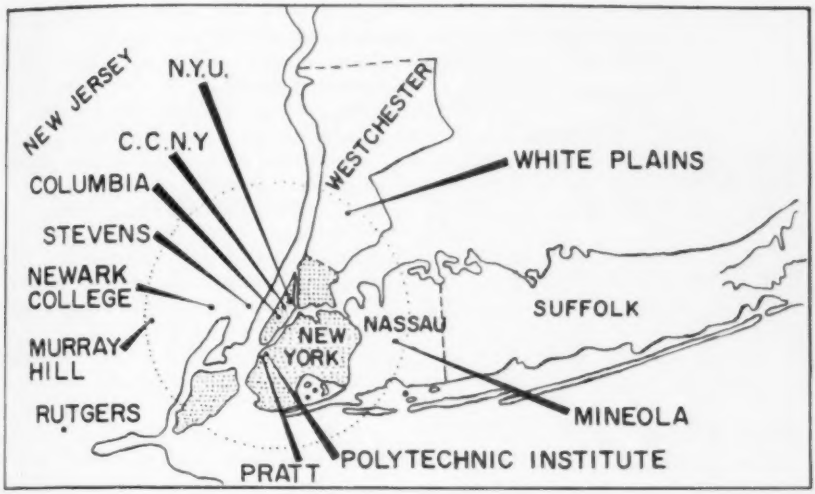


FIG. 1. The New York Metropolitan Area.

following World War II, additional degree programs were inaugurated at the Newark College of Engineering in 1946 and at the College of the City of New York in 1950. Also in the early 1950's, Columbia University extended its day program, which started in the early 1930's, to the evening. Very recently, Pratt Institute entered the scene.

Industry has long recognized the urgent need for education beyond the bachelor's level and has provided incentives to encourage the attainment of advanced degrees on a part-time basis. It is estimated that over 70% of recent graduates are involved in part-time studies either fully or partially subsidized by industry. As a result, part-time enrollment in graduate schools is by far the major share of the total graduate enrollment across the country. This is also true in the New York metropolitan area. Furthermore, the impetus has continued beyond the master's level. Doctor's programs in electrical engineering are also available in the evenings at the Polytechnic Institute of Brooklyn (since 1936), at Columbia University (since 1938), at New York University (since 1947), and at Rutgers (since 1956).

TABLE 1

EVENING GRADUATE PROGRAMS IN ELECTRICAL ENGINEERING; NEW YORK METROPOLITAN AREA

School	Master's Program			Doctor's Program
	Date Inaugurated	Minimum Credit Hours	Thesis	Date Inaugurated
College of the City of New York	1950	32	Optional; 10 credits	None
Columbia University	day; early 1930's eve; early 1950's	32	Project; 2–3 credits	~1938
Newark College of Engineering	1946	30	Required; 6 credits	Expect to 1959–1960
New York University	1938	~30	Optional; ~8 credits	1947
Polytechnic Institute of Brooklyn	1928	30	Required; 8 credits	1936
Pratt Institute	1958	30	Optional; 6 credits	None
Rutgers, The State University	~1932	30	Optional; 6 credits	1956
Stevens Institute of Technology	1930	30	Optional; 5–6 credits	None

TABLE 2

CAMPUS SCHEDULES AND ENROLLMENT, SPRING 1959

School	Campus Schedules				Campus Enrollment								Grand Total
					Master's Level				Doctor's Level				
	Day Hours	Late Afternoon Hours	Evening Hours (After 6:00 P.M.)	Saturdays	Full-Time Degree	Part-Time Degree	Part-Time Non-Degree	Total	Full-Time Degree	Part-Time Degree	Part-Time Non-Degree	Total	
C. C. N. Y.	No	No	Yes	No	0	166	115	281	0	0	0	0	281
Columbia	Yes	Yes	Yes	No	20	164	90	274	12	74	0	86	360
N. C. E.	No	No	Yes	No	0	255	20	275	0	0	0	0	275
N. Y. U.	No	No	Yes	No	8	← 199 →		207	0	← 44 →		44	251
P. I. B.	Yes	Yes	Yes	No	32	195	58	285	19	128	17	164	449
Pratt	No	No	Yes	No	0	3	0	3	0	0	0	0	3
Rutgers	Yes	Yes	No	Yes	0	24	0	24	1	4	0	5	29
Stevens	No	No	Yes	No	0	109	0	109	0	0	0	0	109

Patterns of Study

Referring to Table 1, the pattern of study for the master's degree in electrical engineering is now nearly identical among the various schools in the New York metropolitan area. Usually 30–32 minimum credit hours are required. These include a basic core of courses, such as Transients, Electromagnetic Theory, Network Theory—both active and passive, Advanced Mathematics, and a group of electives in specialized areas. In most schools, the master's thesis is optional.

In the early days, the thesis represented an independent piece of research. In later years, it became a contribution to advanced design. And now, in most schools, it is not required at all. Perhaps this trend is indeed unfortunate, especially since evening studies do not generally permit a close tie between the student body and the faculty. By its very nature of providing for faculty guidance on a problem which normally extends over a period of more than one year, the thesis can serve as a positive link in strengthening student-faculty relationships. Also, it represents an important safeguard in the evaluation of a student's independent ability to apply the advanced knowledge gained through graduate study. Of course, other types of safeguards can be introduced, and, very likely, they do prevail in most schools. However, the value of the master's thesis in this regard deserves strong consideration.

Part-time master's programs in electrical engineering as conducted in the New York metropolitan area are quite equivalent to full-time graduate studies spread over a longer period of time, usually a maximum of five years. They involve identical entrance requirements, identical courses, and very often identical faculty members. The only deviation from this rule is on the thesis, since all full-time students are required to submit a thesis while, for part-time students, a thesis is generally optional in most schools, with the exception of the Newark College of Engineering and the Polytechnic Institute of Brooklyn. Also, in part-time evening studies, the faculty is often augmented by highly qualified practicing engineers in special areas of endeavor, who provide very effective liaison between the college and the profession, to the advantage of both.

The pattern of doctor's studies among the various schools offering such programs is also quite similar. All require dissertation research, qualifying examinations in the major and minor fields, language examinations, approximately 50–60 credit hours of elective and required courses beyond the bachelor's level, and strict guidance by an advisory committee. The minimum residence requirement is usually the equivalent of one year of full-time study.

The scheduling of courses in the New York metropolitan area is described in Table 2. All of the colleges, with the

exception of Rutgers, offer courses during the evening hours, usually after 6:00 P.M. The only college which makes graduate courses available on Saturdays is Rutgers. In several of the listed schools, courses are also scheduled during day and late afternoon hours.

As illustrated in Table 2, on-campus enrollment is divided into three categories: full-time degree, part-time degree, and part-time non-degree. The last category is comprised mainly of students interested in specialized courses without regard to qualifying for an advanced degree. However, a large percentage of these students do decide to change to a degree status following a year or two of graduate studies.

On the master's level, for the 1959 spring semester, there were a total of 60 full-time electrical engineering students enrolled on campus in the New York metropolitan area in contrast to 1,398 part-time electrical engineering students, or an approximate ratio of 1 to 23. On the doctor's level, a similar study indicated 32 full-time students and 267 part-time students, or a ratio of 1 to 8. In summary, the total on-campus enrollment in E.E. comprised of 92 full-time students and 1,665 part-time students or a grand total of 1,757 during the 1959 spring semester.

In Table 3, an attempt has been made to tabulate the breakdown in staff assigned to graduate studies according to rank. The distribution is quite varied among the schools mentioned.

Off-Campus Programs

The industrial shift towards suburban areas rather remotely located from metropolitan colleges has created new problems for advanced education. Because of transportation difficulties, a segment of the professional population has found itself completely isolated from sources of graduate study in electrical engineering. This phenomenon is not peculiar to the New York area alone. It predominates wherever there exist recently developed suburban areas of industrial activities.

One may take an aloof attitude to this phenomenon by excluding it entirely from our advanced educational framework. On the other hand, one may demand the establishment of a permanent graduate center as a community effort with provisions for student facilities and for a resident faculty before any attempt is made to initiate advanced programs. Perhaps the answer lies in the creation of graduate centers. However, since such facilities can only be utilized for a few hours per evening because of the nature of part-time studies, the cost per graduate credit hour becomes prohibitively high, unless an "angel" can be prevailed upon to guarantee full financial support.

As illustrated in Table 3, three of the

TABLE 3

DISTRIBUTIONS OF STUDENTS AND STAFF, SPRING 1959

School	Campus Operations				Off-Campus Operations				Summary Students (EE) Grand Total
	Total Number of Students (EE)	Staff Distribution			Total Number of Students (EE)	Staff Distribution			
		Instructors	Faculty	Adjunct Staff		Instructors	Faculty	Adjunct Staff	
C. C. N. Y.	281	5	7	8	0	—	—	—	281
Columbia	360	11	12	7	0	—	—	—	360
N. C. E.	275	0	7	6	0	—	—	—	275
N. Y. U.	251	0	11	2	283	2	3	4	534
P. I. B.	449	3	21	5	332	3	21	8	781
Pratt	3	0	1	0	0	—	—	—	3
Rutgers	29	0	6	0	85	0	6	0	114
Stevens	109	0	5	3	0	—	—	—	109
Total	1757	*Lecturers			700				2457

TABLE 4

OFF-CAMPUS OPERATIONS, SPRING 1959

Present Off-Campus Programs			Off-Campus Enrollment			
			Master's Level		Post Master's Level	
School	Off-Campus Location	Date Established	Part-Time Degree	Part-Time Non-Degree	Part-Time Degree	Part-Time Non-Degree
N. Y. U.	BTL—Murray Hill, N. J.	1957	246	21	16	0
P. I. B.	Mineola, Long Island	1952*	126	101	0	30
P. I. B.	White Plains, N. Y.	1958	12	28	0	0
P. I. B.	ITT Labs., N. J.	1948	10	25	0	0
Rutgers	Fort Monmouth, N. J.	~1953	55	15	15	0

* Preceded by graduate courses given on Long Island as early as 1942 for credit.

listed schools are involved in off-campus operations in electrical engineering. The NYU-Bell Telephone Laboratories Graduate Center is a very special situation—very likely the only one of its kind in the country. Rutgers operates an off-campus program at Fort Monmouth, N. J., during late afternoon hours. The Polytechnic has organized several off-campus programs. The distribution of staff assigned to these off-campus programs is also shown in Table 3. A more definitive breakdown of off-campus enrollment and locations is illustrated in Table 4.

It is interesting to observe that there were a total of 700 E.E. students attending off-campus in contrast to a total of 1,757 E.E. students attending on-campus. Furthermore, the overall effort which involved 2,457 students constitutes approximately 23% of the 1958 national total reported in the ASEE Yearbook published in February, 1959.

Polytechnic Off-Campus Programs

The Polytechnic has for many years, like most similar schools, cooperated closely with industry and the professional world in the development of curricula in science and engineering to meet the technological needs of its surrounding communities. The graduate effort at the Polytechnic has been sustained by research activities of considerable magnitude and depth. Over three million dollars are expended yearly in support of research and development. The research has not only extended the boundaries of science and technology, but has also provided opportunities to develop a well qualified staff and many advanced courses in new fields of interest. At present, there are over 80 semester graduate courses in electrical engineering listed in the 1958–1959 Graduate Catalog.

The evolution of its present off-campus status in electrical engineering began during the war years. Research in microwaves and linear and nonlinear phenomena resulted in a number of new graduate courses which attracted significant industrial interest—so much so that several of the faculty members were besieged with requests for special off-campus lectures. Among the original participants were Professor Ronald Foster and Professor Ernst Weber. Their unusual approaches stimulated strong requests for basic studies on the graduate level at industrial locations on Long Island. In fact, during 1942 at the Sperry Gyroscope Company, Professor Weber offered for graduate credit Transient Analysis involving Laplace transforms. Professor Foster continued the Sperry effort with Transcendental Functions in 1944 and Functions of a Complex Variable I and II during the summer of 1946.

The systematic development of the graduate program of study on Long Island began in the fall of 1948, when a unique course in advanced electronics was offered by Professor Lynch at the Sylvania Electric Products plant in Flush-

ing. Twenty-five graduate students registered for the course.

This initial effort was enthusiastically received and led to additional requests. By the end of the 1950–1951 academic year, the off-campus program on Long Island had grown from one course to four courses involving three different firms, Sylvania Electric Products, Airborne Instruments Laboratories, and Hazeltine Electronics. The student body grew from an initial group of 25 to 57 students.

Because of the ever growing demand, it became almost impossible to continue with the original plan. Instead, a new approach was conceived. The decision was made to offer a program of graduate studies at a central location for the convenience of all interested parties. The program became known as Polytechnic's Long Island Graduate Studies and had its beginning at the Garden City High School.

Under the new plan, six courses were scheduled for the 1951 fall semester at the Garden City High School. The response was indeed overwhelming, as judged by the fact that 167 students registered, yielding an average attendance of 37 students per class. Consequently, for the 1952 spring semester, nine courses were scheduled, with the result that 207 students attended. The number of students per class averaged around 28. However, it soon became apparent that the program had quickly outgrown available school facilities and it became necessary to move to larger quarters.

Adequate accommodations were located at the Mineola High School which afforded an opportunity to expand the program. During the 1952 fall semester, 12 courses were scheduled at Mineola and they attracted 253 graduate E.E. students.

The program has continually grown. Offerings are now available not only in electrical engineering, but also in mathematics, physics, mechanical engineering, aeronautical engineering and applied mechanics, English, and management. The total student body during the 1958 fall semester consisted of 389 students from 34 different companies. A summary of courses given over the interval 1951–1958 is described in the tabulation at the end of the text.

The development of the Polytechnic's Long Island Graduate Studies has clearly been of major significance. However, the present level of operation is not nearly enough to supply future needs. Consequently, plans are under way for the establishment of a permanent Graduate Research Center by the Polytechnic. The Center will be for full-time research and graduate study during the day and part-time graduate study in science and engineering during late afternoon and evening hours. The research program will provide the resident faculty required for such a large scale operation.

TABLE 5

ADVANCED DEGREES AWARDED IN THE NEW YORK METROPOLITAN AREA: 1956–1958

School	Master's Degree				Doctor's Degree				Grand Total
	1956	1957	1958	Total	1956	1957	1958	Total	
C. C. N. Y.	44	28	42	114	—	—	—	0	114
Columbia	35	35	40	110	4	4	4	12	122
N. C. E.	58	49	48	155	—	—	—	0	155
N. Y. U.	74	69	36	179	1	0	1	2	181
P. I. B.	62	63	70	195	7	2	6	15	210
Pratt	—	—	—	0	—	—	—	0	0
Rutgers	8	5	10	23	—	—	—	0	23
Stevens	26	21	19	66	—	—	—	0	66
Total	307	270	265	842	12	6	11	29	871

POLYTECHNIC'S LONG ISLAND GRADUATE STUDIES
SUMMARY OF COURSES OFFERED: 1951–1958

	Course	Number of Times Offered	Total Registrants
0371	Limit Analysis of Structures	1	13
0372	Advanced Limit Analysis	1	1
0621	Viscous Incompressible Flow	1	17
0622	Viscous Compressible Flow	1	12
0631	Supersonic Flow	2	43
0632	Applied Supersonic Aero. I	2	24
0633	Applied Supersonic Aero. II	1	13
0641	Transonic Compressible Flow	2	34
0642	Subsonic Compressible Flow	2	18
0660	Topics in High Speed Aerodynamics	1	15
0733	Thermal Effects in Structures	2	56
4011	Electromagnetic Theory I	14	350
4012	Electromagnetic Theory II	13	279
4061	Intro. to Antenna Theory I	2	23
4062	Intro. to Antenna Theory II	2	17
4090	Modal Analysis and Synthesis	2	15
4111	Intro. to Newtork Theory I	2	64
4112	Intro. to Network Theory II	2	48
4131	Transients in Linear Systems I	14	341
4132	Transients in Linear Systems II	13	275
4160	Theory of Feedback Networks	2	49
4410	Electron Tube Theory I	3	37
4415	Intro. to Modern Microwave Tubes	1	18
4420	Electron Tube Theory II	3	53
4451	Topics in Electronic Circ. I	4	122
4452	Topics in Electronic Circ. II	4	68
4460	Theory & Appl. of Transistors	3	86
4490	Television Systems	2	18
4510	Pulsing & Synchronizing Circuits	6	104
4530	Broadband Amplifiers	11	261
4540	Feedback Amplifiers	11	224
4550	Radio Noise & Modulation	1	10
4560	Signal Analysis	1	15
4571	Microwave Transmission Lines I	2	38
4572	Microwave Transmission Lines II	2	18
4631	Principles of Feedback Control Systs.	7	198
4632	Feedback Control System Components	6	125
4633	Feedback Control System Synthesis	6	145
4641	Topics in Systems Engineering	1	27
4650	Transducers & Electro-Mech. Ntwks.	1	5
4661	Fundamentals of Digital Computers	4	112
4662	Fundamentals of Analog Computers	3	76
4750	Audio Engineering Principles	2	34
5519	Technical Writing I	1	15
5520	Technical Writing II	1	13
5672	Research & Engineering Management	1	26
6140	Vector Analysis	22	528
6180	Elements of Function Theory	22	568
6301	Transcendental Functions I	1	17
7311	Dynamics of Machines	1	11
7312	Mechanical Vibrations I	1	22
7511	Mechanics & Thermo. of Fluid Flow I	1	26
7512	Mechanics & Thermo. of Fluid Flow II	1	12
8401	Intro. to Modern Physics I	3	37
8402	Intro. to Modern Physics II	3	31

Also, the Polytechnic recently inaugurated an off-campus graduate program in the Westchester area. Classes are being held in the White Plains Senior High School. During the 1959 spring semester, four E.E. courses were scheduled and 40 students attended. A growth similar to the Long Island program is envisioned in this area.

The Polytechnic is also offering a very limited program of one or two basic graduate courses per semester at the ITT Laboratories in Nutley, N. J. The courses are generally taken for transfer credit. Not more than ten credits earned off-campus in this program are acceptable by the Polytechnic for the master's degree.

Conclusion

Although the pattern of part-time graduate study in the New York metropolitan area is quite diversified, nevertheless a strong effort is being exerted to meet the needs of the professional community without sacrificing academic standards. The schools are conscious of their obligations and are providing educational stimuli for truly creative engineers and scientists to constantly advance themselves through graduate study. Furthermore, these schools are helping to attract highly qualified people to this area because advanced education is available on a part-time basis.

Table 5 illustrates the number of advanced degrees in electrical engineering awarded in the New York metropolitan area. In June, 1958, 265 master's degrees were awarded as well as 11 doctor's degrees. The total of 276 advanced degrees is practically 16% of the national summary. The overall effort is certainly not insignificant.

Acknowledgment

The author is indeed grateful to the following colleagues for their helpful cooperation in making data available for this presentation.

Dean Harold Wolf
Professor Ralph J. Schwarz
Professor Irving P. Orens
Professor James H. Mulligan
Professor Haroun Mahrous
Professor James L. Potter
Professor William L. Sullivan

They are respectively associated with the following schools.

College of the City of New York
Columbia University
Newark College of Engineering
New York University
Pratt Institute
Rutgers, The State University
Stevens Institute of Technology

COOPER UNION STUDIES PROGRAM

The Cooper Union for the Advancement of Science and Art has announced receipt of a grant of $25,000 "for general support of its activities" from the Ford Foundation.

Dr. Edwin S. Burdell, president of the Cooper Union, said that plans are to use the grant for "thorough-going studies of our undergraduate engineering program, of a new approach to evening education in the physical sciences and engineering, and of the possibilities of work on the graduate level."

The results of the study, asserted Dr. Burdell, would be applied when Cooper Union's new School of Engineering building, under construction, is completed.

Part-Time Graduate Electrical Engineering Programs in the San Francisco Bay Area

JOSEPH M. PETTIT

Dean, School of Engineering
Stanford University

Geographic Setting

It will be helpful to commence with some background data, the first being the geographic setting of the San Francisco Bay Area. Although the city of San Francisco is the hub of the area, there are two outlying regions which dominate the picture so far as population, industry, and higher education are concerned. These are the Peninsula and East Bay areas. The Peninsula extends southward from San Francisco along San Francisco Bay to include the city of San Jose on the south. The East Bay includes the urban areas of Oakland and Berkeley, and extends eastward across the hills about 20 miles to include the rapidly growing communities of Walnut Creek and Concord. From the population standpoint, the metropolitan area includes about 2½ million persons, of whom only 790,000 reside within the San Francisco city limits. Oakland and Berkeley together comprise 517,000 persons. On the Peninsula the combined population from Redwood City, through Palo Alto, to San Jose includes about 250,000 persons.

Academic

The academic setting is one in which there are many institutions of higher education, among them being two major universities which offer graduate work in engineering, the University of California in Berkeley, with a total student enrollment of 19,000, and Stanford University, situated adjacent to Palo Alto in the Peninsula area, with about 8,000. The newest arrival in the field of graduate engineering education, though long established otherwise, is San Jose State College, with a total student population of more than 10,000.

Industrial

The industrial setting is pertinent to any discussion of graduate part-time education, because it is from industry that the part-time students come. The industry in the Bay Area could be described generally as young, highly technical (high ratio of research and development compared to production) and strongly concentrated in the electronic and aeronautic fields where there has been on the one hand a genuine need for engineers with advanced training in new subject matter areas and on the other hand a nationwide shortage of manpower, resulting in keen competition and intensive recruiting. The electronics industry alone has grown from a very small size prior to World War II up to more than 30,000 employees in 1958. The industries have built new plants in the suburban areas, with many of them to be found clustered in the Palo Alto and San Jose areas. The companies are predominately of local origin, such as Hewlett-Packard and Varian Associates, although many of the major companies, such as Sylvania, General Electric, Westinghouse, and Lockheed, have set up laboratories and production facilities in the Bay Area.

The historical situation has been a strong determining factor in the nature of the graduate programs as they exist today in the Bay Area. In the prewar depression years, there was little industry and there would have been little incentive to accommodate the needs of a good

Presented at the Annual Meeting of ASEE in Pittsburgh, June, 1959.

part-time program. Had the programs started then, it is certain that their character would have been different from what it is today.

Present Programs

The present scope of the part-time graduate activity in the Bay Area is quite substantial, at least compared to its nonexistent status until the postwar period, even if not in comparison with the larger programs in the New York and Los Angeles areas. The two universities, Stanford and the University of California at Berkeley, are still concentrating on their regular daytime enrollment, and even the part-time students attend the daytime classes. Nevertheless the part-time enrollment is significantly large. At Stanford there are 296 part-time industrial students out of a total engineering graduate enrollment of 743 students; in electrical engineering there are 153 out of 371. Employees of 31 companies participate in the Stanford program. At Berkeley the part-time enrollment is a smaller proportion, about 50 out of a total of 550. At San Jose State College, where prior to 1958 there were no engineering graduate offerings, there is now an M.S. program under way in electrical engineering, with some 60 students admitted. The San Jose State classes are in the evening, and are the only degree-credit evening classes in the Bay Area. The University of California has decided after one year to discontinue an experiment with evening graduate classes on the Peninsula at Sunnyvale, although a similar program at Livermore in the East Bay will go ahead with about 15 students. The U. C. program requires that the student spend one semester at Berkeley in "full-time residence," measured as 4 units or more, and that one half of his total M.S. units be taken at Berkeley.

Stanford Program

From this point on the writer will take the liberty of describing the Stanford program in more detail, since he is personally familiar with it and since it includes the bulk of the part-time students in the area. The Stanford experience provides considerable insight into the academic issues and also the local industrial situation. In its 5 years of operation the Stanford program has not only grown in size, but also as operating experience has been gained there has been opportunity to reaffirm and refine the objectives of the program and to organize and improve the operating arrangements. The result to date has been generally satisfactory, and there is every intention to continue and expand the program.

Objectives

The objectives of such a part-time program may seem obvious, but they are worthy of review at this point. Clearly, there are three interested parties, the individual student, his employer, and the University. The aims of all three should be preserved and enhanced, and the arrangements and policies should promote these aims. The student's aims include greater professional ability, i.e., the capacity to attack successfully the more advanced problems of contemporary technology, and also of course the prestige and earning capacity represented by the higher degrees. The employer has two principal objectives: he needs to upgrade his present employees to enable them to tackle the difficult technical problems confronting the organization, and he wants to recruit the best possible new young engineers. The opportunity for part-time graduate study is almost a necessary fringe benefit for recruiting the best engineers. The University's objectives include the basic one of attracting a supply of the best possible graduate students, which constitute the raw material of the educational process, and, to the extent that these can be derived from industry on a part-time basis under arrangements which are financially self-supporting, the part-time students from industry provide a desirable enlargement of the graduate population. There are incidental benefits to the University in the resulting closer ties with local industry, especially the many companies who have located near Stanford for reasons of technical liaison and other considerations.

Standards

It is important, of couse, that academic standards be maintained, and this Stanford has sought to preserve through the medium of a single, integrated program of daytime classes, together with highly selective admission requirements. Because of the multiple burden carried by the part-time student who is simultaneously a graduate student and an industrial employee (plus being a husband and father also, in the typical case), it requires a better student to maintain the academic pace, and hence our admission requirements for part-time industrial students are higher than for the full-time resident student. The implications of these several issues are evident in the name which Stanford has given to the program, i.e., the Honors Cooperative Program.

A further item in the academic arrangements is that in order to preserve an intgerated program in which the academic pace is maintained by the full-time resident students, we have set an arbitrary ceiling on the number of part-time students, whereby on the average they constitute no more than one-third of the class population.

Our operating experience to date indicates that the part-time group includes many excellent students, and indeed were it not for their additional burden of industrial responsibilities they might on the average constitute a better group than the full-time students.

Our graduate program in general has been aimed at providing a comprehensive upgrading of the student, including the increasing of his perspective and understanding of the basic physical and mathematical sciences. This is in contrast to serving another, different objective for which there is always demand on the part of both students and employers, the providing of an assortment of specialized skills, which in highly focused courses would serve a short-range goal of helping the engineer on his immediate project assignments. Thus we have not instituted specialized courses in limited subject matter areas such as radar.

Although the company may wish to and in most cases does provide the student with a full-time salary, as well as paying his tuition, we feel that the student must be able to allocate a substantial block of his time to graduate study. Thus we prefer that he take two courses per quarter on the average. While this detracts from his full-time attention to the company's projects, it has the long-range benefit of permitting the completion of an M.S. degree in two years, rather than having it drag on for four years or longer. This is one of the problem areas in our arrangements, being merely another example of the human conflict between short-range and long-range goals.

Another aspect of this conflict is that the important feature of graduate study is symbolized by the word *study*, which is sometimes mistakenly taken to be synonymous with *attendance* at graduate lectures. Thus to take two courses per quarter requires a block of 18 hours a week including preparation time, and we feel that the company should provide a substantial part of this. In the present employment market we have been reasonably successful in gaining acceptance of these principles on the part of the employers, and they are willing to put up with the daytime absence from work including the commuting time. Fortunately the geography and traffic conditions are such that it is only a few minutes' drive from most of the companies to the Stanford campus.

Financial Aspects

The financial arrangements are important in the operation of a priviately supported university such as Stanford. The arrangement is a contractual one with the company rather than with the student, involving certain costs on the part of the company as well as certain privileges. Tuition is of course paid by or for each student, usually but not always by the company, and sometimes on a deferred basis pending completion of the degree. At typical privately supported universities in the U. S., however, the tuition does not cover the full cost of instruction, and at Stanford the average teaching cost is more than twice the tuition. Thus in the operation of the University, the remainder of the cost is made up from gifts and other support from individuals

and institutions. It has been our feeling that in the case of the part-time industrial student the employer is a substantial beneficiary, and hence through a supplementary payment we ask the employer to provide a sum which matches the tuition paid. This supplementary payment goes directly to the academic department in which the student is majoring, and is put solely into teaching payroll. The contracts are initially made on a five-year basis, so that long-range commitments for new faculty can be made. As stated earlier, there are now 31 companies on this program, all of whom subscribe to the principle and practice of this financial operation.

So far as privileges to the companies are concerned, only employees of these companies can enroll in engineering on a part-time basis. Partial tuition is charged, in proportion to the number of units for which the student is enrolled. No other industrial students have this privilege, but instead would have to pay full tuition even if they took only one course. Thus the companies on the program have a substantial recruiting advantage over their competitiors in the area.

Degrees

Students on the Stanford Honors Cooperative Program are candidates for the regular graduate degrees offered by the University, including the M.S. degree primarily. This is a standard one-year degree for a full-time student, and proportionately longer for the part-time student. There is no thesis required for the degree; there has not been at Stanford for 11 years, except in a few situations where it is a departmental requirement. Thus in engineering, where a thesis is not required, a student can qualify for the M.S. degree by completing 45 quarter units of work, distributed as to subject matter and level in accordance with the requirements of the individual departments.

There is also the two-year degree of Engineer, which does include a thesis requirement, being comparable to the M.S. thesis at most schools. A total of 90 units is required for this degree, of which some are allowable for the thesis work. Present policy would permit the thesis investigation to be carried out in connection with the student's industrial work, provided that there were no restrictions due to military security or company privacy, and that the work was capable of supervision by, and of interest to, one of the faculty.

The highest degree is the Ph.D., which involves the usual requirements of a substantial course program comprising both breadth and depth, together with the passing of qualifying examinations, the conduct of research and preparation of a dissertation thereon which comprises an original contribution to knowledge in the engineering sense. After the student has completed his course work, qualifying examinations, and language, it is our present practice in electrical engineering to require the student to take essentially a leave of absence from his company and be physically resident with one of our faculty research teams in our very large on-campus sponsored research program. This requirement is partly to benefit the student by the association with faculty member and students, although we realize that the intellectual level of his company environment may be equally good. But it is our further desire that we benefit from his presence, and that accordingly our research program be augmented thereby. This research program is exceedingly important in the life of the University, and is the means of financial support for faculty and graduate students, as well as for the facilitation of the experimental aspects of first-class research. The financial arrangements differ from student to student. It is usually possible for the University to provide a full-time assistantship, although this is at a lower pay rate than the student received from his employer. We have no objections if supplementary arrangements are made with the employer through fellowships, loan funds, or partial compensation for limited contact with the company, not to exceed one day per week.

It may help in providing further perspective if some graduation statistics are given. In 1958 we graduated a total of 65 B.S., 100 M.S., five Engineer, and 28 Ph.D. students in electrical engineering.

Of these graduates, 32 M.S., one Engineer and 3 Ph.D. students were on the Honors Cooperative Program.

It should be noted in passing that Stanford has no part-time undergraduate program. At the undergraduate level Stanford is primarily a full-time residence university. All students pay full tuition and must carry the minimum academic load that is considered to be full-time.

Future

As to the future, the part-time industrial program is expected to grow in selected academic fields where there is still capacity. In electrical engineering the program is now operating at full capacity, and we can expect San Jose State College will carry an increasing share of the total area load. Our main objectives in the academic world are to build up the best possible full-time resident faculty, supported by an adequate student enrollment and a well financed research program on the campus. To the extent that we can at the same time conduct a self-supporting part-time program which is of service to the local engineers in industry and to their employers, we are more than willing to cooperate.

SCIENTIFIC INFORMATION PROJECTS

The National Science Foundation has announced support totaling $286,900 for three projects to develop mechanized systems and other advanced methods for improving the availability of scientific information in the fields of chemistry and metallurgy.

Chemical Abstracts Service of the American Chemical Society, at Columbus, Ohio, received grants totaling $127,700 for two projects. A third grant for $159,200 will support a test program at the Center for Documentation and Communication Research, School of Library Science, Western Reserve University, Cleveland, Ohio, according to Dr. Alan T. Waterman, Foundation director.

Investigation of mechanical aids to chemical documentation will be performed by Chemical Abstracts Service with a $69,800 grant for a period of one year.

One aspect of the project will involve ways to mechanize chemical data in order to correlate structures of chemical compounds with their properties and uses. The development of a system for correlating these data would permit the Service to answer, for example, a question regarding the number of chemical compounds containing a particular element that also have boiling points within specific ranges.

A second grant to Chemical Abstracts Service, $57,900 for one year, involves research into the semantic content of chemical literature. Part of a Chemical Abstracts program to mechanize wherever possible the processing and searching of information in chemistry, the study will attempt to determine methods for reducing the variety of word forms needed to express concepts in a sub-discipline such as biochemistry. Concept dictionaries will be prepared and applied experimentally to the processing of abstracts. Experimental searches will be conducted, using machine techniques. Machine programming needed to convert stored information automatically back to an intelligible form will be investigated.

The Western Reserve University grant will help support a large-scale test program to evaluate procedures developed for the automatic processing and searching of literature of interest to metallurgists. The funds will be used by the Center in working with not only the metallurgical literature proper, but also material of interest to metallurgists in such fields as physics, chemistry, and engineering. The program will ultimately include test searches and related studies designed to evaluate the results achieved with the mechanized procedures. In addition, the use made of the mechanized searching service by metallurgists will be analyzed.

The New York University Graduate Center at Bell Laboratories

SIDNEY S. SHAMIS

Associate Professor of Electrical Engineering
New York University

On June 10, 1959, some 5,200 academic degrees were awarded at the 127th annual Commencement Exercises of New York University. Included among the degree recipients from the 14 colleges and schools of the University were 95 from the College of Engineering for whom this event held uncommon significance; these were the first successful degree candidates to emanate from the New York University Graduate Center at Bell Laboratories.

The establishment of this Center just two years ago marked the initiation of an experiment in graduate engineering education which has been watched with great interest in many quarters. That such a high degree of interest should be displayed by observers outside of the University and the Laboratories has not been surprising; certainly, the full-scale daytime operation of a degree-granting branch of a university on the premises of an industrial organization fairly invokes the appraisal of all professional educators and those interested in professional education. The recent graduation of the first class from the Center affords an appropriate opportunity for reporting on the initial two years of its operation.

Before proceeding with a description of the activities conducted at the Graduate Center, we will examine briefly some of the history preceding its establishment. In 1948 the Bell Telephone Laboratories staff satisfied itself that the normal undergraduate engineering preparation acquired by young engineers embarking upon research and development careers was not equal to the needs of the Laboratories. Accordingly, the Communications Development Training Program was instituted to supplement the background of such personnel by an in-plant training program on company time. Beginning in 1948, all new members of the Laboratories' technical staff at the B.S. and M.S. degree levels were required to participate in this three-year program of combined work and formal classroom training, augmented by a suitable series of rotational work assignments.

The curriculum, as originally constituted, emphasized training in Company technologies, but not without the inclusion of certain courses of a fundamental nature. Between 1948 and 1957 the curriculum was subjected to continuous modification, becoming progressively more "academic" in character. Indeed, a number of courses were presented by faculty members of nearby academic institutions. Such courses were not given for academic credit, however, since they were not listed among the regular offerings of these universities, nor were their contents subject to the control of the university faculties.

By late 1956 it had been concluded that one of the Bell Telephone Laboratories' primary educational objectives, that of providing all of its young college recruits with a common body of basic knowledge, might be achieved most satisfactorily through a program administered by a university on Company premises. Further, it was deemed desirable that this program should not only fulfill the expressed Company objective, but that it should also satisfy the personal objective of many of the students enrolled in the program—the acquisition of a gradu-

Presented at the Annual Meeting of ASEE in Pittsburgh, June, 1959.

ate degree. The formulation of a curriculum which would achieve both purposes was evolved from a series of discussions among University and Laboratories representatives during the spring of 1957; this was followed by the conclusion of an agreement between the respective organizations creating the New York University Graduate Center at Bell Laboratories.

The Graduate Center was established as a branch of the Graduate Division of the College of Engineering, dictating that its operation be conducted on the basis of a few fundamental precepts: the same admissions requirements, the same degree requirements, and the same academic standards as those already in effect for the Graduate Division pertained. Further, the University would administer the center through a resident staff of University personnel, headed by a Director and including a Recorder's office (branch of the Registrar's office) and the necessary secretarial, clerical, and administrative assistance. In addition, courses offered at the Center would be open to qualified applicants other than Bell Telephone Laboratories employees; such registration would be limited by the availability of classroom space in terms of the size of the enrollment from the Laboratories during a given session. Finally, it was recognized at the outset that since the Laboratories hired its new employees on the basis of a nationally conducted recruiting program, the variation in educational backgrounds among the members of the Center's incoming classes would be considerable. Accordingly, a group of intensive summer courses was made available to those newly admitted students at the Center lacking in background in advanced calculus, electromagnetic fields, passive networks, and active networks.

Two years have passed since the basic decisions described above were made. The Graduate Center has been administered in consonance with the fundamental precepts outlined at the time of its establishment, with the University maintaining complete control of admission requirements, scholarship standards, regulations governing the granting of degrees, and content of courses. As a result of consultation among University and Laboratories representatives, the programs of courses now offered constitute a modification of the curriculum which was instituted initially. Besides the program of studies leading to the Master of Electrical Engineering degree, curricula are now available which may lead to the degrees of Master of Mechanical Engineering and Master of Science in Engineering Mechanics. Of the 95 degrees awarded to Graduate Center students on June 10, 1959, ninety-three were in electrical engineering, the remaining two in engineering mechanics.

The Accomplishments

In submitting a progress report on the operation of the Center, one must gauge accomplishment in terms of the degree to which the needs and objectives of the program's participants—the students, the University, and the Laboratories—have been realized. Perhaps the most convenient point at which to begin is that at which the student is admitted to Graduate School. Since most of the applicants specify an M.E.E. degree objective, let us consider such a student. First, the student may be required to enroll for summer work carrying no graduate credit. If his undergraduate degree is in E.E., he may be asked to register for Advanced Calculus or Electromagnetic Fields or both; since these are required courses in the undergraduate E.E. curriculum at New York University, a knowledge of their contents is assumed in presenting material at the graduate level. If the student's undergraduate degree is in physics, he is generally required to register for Passive and Active Networks unless, of course, his background in these areas is adequate. At the conclusion of the summer session, the student may register for graduate work.

Registration for course work at the Graduate Center is effected through the same procedures as those employed at University Heights. At the time of initial registration the student, in consultation with a graduate adviser, prepares a program of studies which will satisfy the degree requirements; in addition, the pro-

gram of courses for the then-current term is approved. The latter procedure is repeated during the registration period for each subsequent semester until the award of the degree; changes in the degree program prepared at the initial registration may be effected at these conferences with the graduate adviser. All additional registration procedures are completed in the Recorder's office at the Graduate Center.

In formulating his program leading to the M.E.E. degree, the student is restricted in his ability to select courses as a result of the requirements imposed by the University on the one hand and the Laboratories on the other. The University requires that all M.E.E. candidates take the following 3-credit courses: Functions of a Real Variable, Functions of a Complex Variable, Fundamentals of Network Theory, Fundamentals of Electromagnetic Fields. The Laboratories stipulates that these same students must complete the courses listed below:

Vacuum Tube and Transistor Circuits	(6 credits)
Introduction to Theoretical Physics	(3 credits)
Logic and Switching	(3 credits)
Probability and Statistics in Engineering	(3 credits)

All students in the E.E. curriculum at the Graduate Center must include 27 credits of prescribed courses in their degree programs; a minimum of 36 course credits is required for the degree.

In the present arrangement, students complete the requirements for the master's degree during the course of two academic years. First-year students attend school on three days each week and are required to report to their Laboratories technical departments on the other two; the student has no work obligations on the three days during which he attends classes. Second-year students are scheduled for classes on two days each week, reporting to their respective departments on the other three. Students are assigned twelve semester hours of classes during each semester of the first year of attendance and a total of 15 or 18 semester hours during the second; all classes are scheduled for two 75-minute meetings per week. Class enrollment is limited in size insofar as is practicable, and is seldom permitted to exceed 35. The program of courses presently pursued by candidates for the M.E.E. degree is outlined below:

First Year

First Semester	*Second Semester*
Functions of a Real Variable	Functions of a Complex Variable
Fundamentals of Network Theory	Fundamentals of Electromagnetic Fields
Introduction to Theoretical Physics	Logic and Switching
Vacuum Tube and Transistor Circuits	Vacuum Tube and Transistor Circuits

Second Year

First Semester	*Second Semester*
Probability and Statistics in Engineering	Physical Electronics or Time Series } optional
Two of the following 2-semester sequences:	
Introduction to Microwave Networks	Microwave Measurements
Electrical Transients	Electrical Transients
Network Synthesis	Network Synthesis
Feedback Control Systems and Servomechanisms	Feedback Control Systems and Servomechanisms
Wave Propagation	Wave Propagation
Fundamentals of Solid State Electronics	Fundamentals of Solid State Electronics

Meeting Student Needs

Having examined the Graduate Center operation in some detail, we can now attempt to gauge the degree to which the needs and objectives of the program's largest group of participants—the students—are met. Probably nearest and dearest to the student's heart is the fact that since participation in the program is a Company assignment for all new college recruits, the student pays no tuition to the University, attends classes on Company time, and is paid standard rates for full time. Thus, the student begins to receive a substantial income immediately after earning his baccalaureate degree, and is not required to make financial sacrifices to pursue graduate work. Further, seniority in the Laboratories is established early, not only in terms of length of service, but also in terms of his acquisition of familiarity with the engineering and management aspects of the Company's operation. To the student who is unable to attend graduate school on a full-time basis for financial reasons, and to the student who is anxious to proceed to an industrial affiliation without delay, this program represents a most attractive compromise.

Of course, the program is not without its disadvantages to the student. First, he must condition himself to a dichotomous existence in which there is continuous competition for his energies between school and company projects. To be sure, the Company emphasizes that the prime obligation of the employee who is enrolled in the program is to his studies. However, this does not always prove to be the case—either as a result of the demands made by an immediate supervisor or as a result of the employee's self-generated interest in a particular Company project. Further, since successful completion of the program is regarded as a condition of employment by the Laboratories, the student encountering academic difficulty is frequently beset with misgivings concerning the effect which this will have on his company status.

Students at the Graduate Center are also subjected to certain deprivations from a purely academic standpoint. First, since faculty members who teach at the Center also have obligations to meet at University Heights (some 40 miles from Murray Hill), they are not as readily available for consultation and discussion as one might expect on the campus. Another degree of freedom not available to the student at Murray Hill is the opportunity to select from the wide range of courses offered at the usual graduate school. If they were free to formulate their own programs, many students would probably select a somewhat less stringent array of courses than that provided at the Graduate Center.

The Faculty

Another group of participants with a stake in this program is the faculty. Teaching at Murray Hill is pleasant in terms of the very satisfactory physical facilities which are provided by the Laboratories and the generally high quality of the students. On the other hand, as noted previously, the fact that some forty miles separate University Heights and Murray Hill presents obvious difficulties. To be sure, professors who participate in the program are compensated for their incurred travel expenses; further, they are provided with additional remuneration in recognition of the fact that the increase in commuting time attending a Murray Hill assignment exceeds two hours. However, this does not obviate the fact that a Graduate Center teaching assignment detracts from the time which a faculty member can devote to his research program at the University.

From the standpoint of the Laboratories, the arrangement described herein probably constitutes a major step toward realization of an integrated program of advanced study and company training. The University provides instruction in courses of a fundamental nature during the first two years of the program, while the Laboratories, through its own personnel, conducts courses in the specific technologies with which it is concerned during the third and last year. Participation by the University is also advantageous to the Laboratories in the sense that it relieves the Company of the personnel problems involved in detaching its own scientists from their normal pursuits for

teaching assignments. The Graduate Center program, of course, is an expensive one; however, when viewed in terms of the fact that the Laboratories would conduct its own program (as before) if the University were not involved, the departure is probably not serious from a financial standpoint.

In summarizing this progress report on the first two years of operation of the New York University Graduate Center at Bell Laboratories, it is gratifying to note that this experiment in graduate engineering education has been conducted successfully to date. The past two years have been characterized by a long series of adjustments in all quarters; I am confident that this process will continue and that most of the disadvantages cited earlier cannot help but fall victim to the combined efforts of two progressive organizations and an outstatnding student body.

Teaching Positions Available

ADDITIONS TO MECHANICAL Engineering Staff at all professorial ranks. Attractive possibilities in an expanding graduate, undergraduate, and research program. Write to Donald M. Vestal, Jr., Head Professor, Mechanical Engineering, Auburn University, Auburn, Alabama.

CIVIL ENGINEERING-STRUCTURES. Opportunity to head structural division, teaching and directing undergraduate and graduate programs. Attractive possibilities in an expanding graduate and research program. Top salary and rank appropriate to qualifications. Ph.D. preferred. Positions now open. Write to L. M. Laushey, Head, Civil Engineering, University of Cincinnati, Cincinnati 21, Ohio.

HEAD, DEPARTMENT OF MOTORS; also head, Department of Mechanics; at U. S.-type engineering school. Teaching and research. Contract with liberal salary, income tax free. Travel paid; house provided, partly furnished; electric kitchen. Ideal climate. Write air mail to President S. S. Steinberg, ITA, São José dos Campos, São Paulo, Brazil.

CHAIRMANSHIP IN CIVIL ENGINeering. Graduate and undergraduate teaching and research opportunities. Must have doctor's degree. Write Walter J. Seeley, Dean, College of Engineering, Duke University, Durham, North Carolina.

CIVIL ENGINEERING APPOINTment: McMaster University. The Department of Civil Engineering and Engineering Mechanics solicits applications for a staff position in a new school with a stimulating research environment. The candidate should possess a graduate degree (preferably the doctorate) based on specialization in structures, and some experience in lecturing and research direction. Duties will include undergraduate and graduate instruction, and good research facilities are available. Appointment will be made at the rank of assistant or associate professor, depending upon qualifications and experience. Enquiries and the names of three references should be addressed to: Dr. J. W. Hodgins, Dean of Engineering, McMaster University, Hamilton, Ontario, Canada.

ELECTRICAL AND MECHANICAL staff openings at assistant, associate and full professor levels to teach in liberal arts college with new Engineering Science program. M.S. or Ph.D. required, industrial experience desirable. Write to S. Goldstein, Chairman of Engineering, Hofstra College, Hempstead, Long Island, New York.

ELECTRICAL ENGINEER TO TEACH electronics. Ph.D. or M.S. and experience. Nine months basis. Academic rank and salary open. College located in Northern California. Apply to H. F. Langdon, Head, Engineering Department, Chico State College, Chico, Calif.

MECHANICAL ENGINEERING teaching positions. Men needed in the fluids-heat transfer-thermodynamics-aerodynamics area, in the theoretical and applied mechanics area, and in nuclear engineering. Large and rapidly growing graduate program through D.Sc. Sponsored research encouraged. No limitations on rank. Salary and rank commensurate with educational background and experience. Apply: C. T. Grace, Mechanical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

ASSISTANT AND (OR) ASSOCIATE Professor of Electrical Engineering with interest and experience in one of the following areas: electromagnetic theory, information theory, digital computer logic and numerical methods, solid state. Ph.D. required. Combination of research, graduate and undergraduate teaching. Address inquiries to Dr. C. Polk, Head, Department of Electrical Engineering, University of Rhode Island, Kingston, Rhode Island.

TWO CIVIL ENGINEERING FACulty positions open. Candidates must have doctor's degree and assist in establishing graduate program in Civil Engineering. Teaching loads will be light, allowing opportunity for research. The undergraduate course is ECPD accredited and doctorates are offered by the university in mathematics, physics, chemistry, and in many other fields. Salary and rank open. Write Dean of the School of Engineering, Vanderbilt University, Nashville 5, Tenn.

CIVIL ENGINEERING STAFF POSItions in Sanitary Engineering and in Highway and Soil Mechanics. M.Sc. degree required and experience preferred. The positions will require teaching at undergraduate and postgraduate levels and supervision of laboratory work. Salary and rank will be determined by academic standing and experience. Apply to Civil Engineering Department, University of Saskatchewan, Saskatoon, Sask.

TEACHING IN PUERTO RICO. PH.D. teaching positions open. English or Spanish speaking. Opportunities in expanding civil, electrical, mechanical, chemical, industrial, and general engineering departments. Research interest imperative. Rank and salary will depend on qualifications. Write to: Dean of Engineering, University of Puerto Rico, Mayaguez, Puerto Rico.

MECHANICAL ENGINEERING—ASsistant or Associate Professor for teaching and research in fluid dynamics, gas dynamics or related area. Advanced degree required. Also, two openings for recent graduates with Master's degrees in Mechanical Engineering. Salary schedule amongst highest in Canada. Applications with full particulars should be sent to Head, Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, Sask., Canada.

EXPANSION OF GRADUATE WORK in Electrical Engineering at Syracuse University has created several openings at the Assistant and Associate Professorial ranks. Except in very unusual circumstances, applicants should have a Doctorate in Electrical Engineering or a closely allied field. Opportunities exist for combination of teaching and research during the academic year, and for summer employment on research. Teaching is primarily at the graduate level. Salary depends on the experience of the individual, but in most cases the yearly salary (for 11 months work) is reasonably competitive with industry. Write to Dr. W. R. LePage, Chairman, Department of Electrical Engineering, Syracuse University, Syracuse 10, New York.

ENGINEERING MECHANICS: POSItion available to combine teaching of undergraduate and graduate courses with opportunities for research. Expanding graduate program requires that the applicant must have Ph.D. or equivalent evidence of research potential. Salary and level of appointment determined by education and experience. Write: E. J. Marmo, Department of Engineering Mechanics, University of Nebraska, Lincoln 8, Nebraska.

PROFESSOR TO BE RESPONSIBLE for graduate and undergraduate courses and to participate in research in the fields of theoretical and applied mechanics. Ph.D. required. Salary open. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

POSITIONS AVAILABLE FOR teachers of Electrical and Mechanical Engineering, and for teachers of Mathematics. M.S. degree is the minimum requirement; the Ph.D. is desirable. Salary and rank will depend upon qualifications. Excellent fringe benefits. Apply to: Earle M. Morecock, Chairman, Division of Applied Science, Rochester Institute of Technology, Rochester 8, New York.

ELECTROMAGNETIC THEORY. AN associate or assistant professorship is available in the E.E. Department, Rensselaer Polytechnic Institute for a person qualified in EM theory or related fields. Teaching experience and Ph.D. required. Salary and rank dependent on demonstrated ability and experience. The individual in this position will be expected to divide his time between teaching and research. Write, including resume, to W. R. Beam, Head, E.E. Dept., Rensselaer Polytechnic Inst., Troy, N. Y.

STAFF OPENINGS IN CHEMICAL, Civil, Electrical, and Mechanical Engineering at Ph.D. and M.S. levels. Excellent opportunities to work in an expanding graduate program. Salary and rank will depend on qualifications. Address: Dean of Engineering, New Mexico State University, University Park (Las Cruces), New Mexico.

TEACHING POSITION AVAILABLE in the Thermodynamics, Heat Power area in the Mechanical Engineering Department at a private college with high academic standards. Located in a small community with inherent advantages but strategically close to large centers enabling professional society activity and contacts. Rank and salary commensurate with education and experience. Address inquiries to Head, Mechanical Engineering Department, Lafayette College, Easton, Pennsylvania.

ELECTRICAL ENGINEERING, ASSOciate or Professor, M.S. or Ph.D. degree required. Opening in electronics or power systems. Salary commensurate with experience, possibly $8,500. Position available now or September 1960. Write to: M. L. Manning, Dean, Division of Engineering, South Dakota State College, Brookings, South Dakota.

ASSISTANT PROFESSOR TO TEACH Fuels and Lubricants and to be responsible for the laboratories in this course. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

ENGINEERING MECHANICS: POSITION available to combine teaching of undergraduate and graduate courses with opportunities for research. Expanding graduate program requires that the applicant must have Ph.D. or equivalent evidence of research potential. Salary and level of appointment determined by education and experience. Write: E. J. Marmo, Department of Engineering Mechanics, University of Nebraska, Lincoln 8, Nebraska.

Civil Engineering Division Bulletin

A Message From Chairman Downing

It will strike you deeply, as it has your officers, to learn of the recent sudden passing, unexpectedly, of Professor Alton D. Taylor, Ohio Northern University, Ada, Ohio, Chairman of our Committee No. 1—"Educational Policy." Charles E. Cutts, head of the Department of Civil Engineering, Michigan State University, has been appointed to take over the program of this Committee, and Carl L. Shermer, Ohio University, Athens, has been added thereto for the unexpired term of the late Professor Taylor.

Our Committees now are well under way in their planning and we look forward to an outstanding program for our June meeting at Purdue.

I take this opportunity to solicit the support of each member of the Civil Engineering Division to cooperate personally in assisting ASEE in broadening its active membership by personally inviting outstanding educators in your area who are not now members of the Society to affiliate in order that ASEE may have the benefit of their thinking as it moves on to even higher goals.

At your request, if desirable, I am certain the President of the Society would be pleased to extend an invitation of membership to such individuals personally.

You might scan the list of industries which are Affiliate Members to make certain that those organizations in your area that are not now included, be invited to affiliate.

It is felt that perhaps the greatest need today in engineering education is for faculty members who are aware of the interrelationship which exists among the various disciplines. There is need for men who recognize the universality of basic principles. If engineers are to be able to solve the increasingly complex problems which are facing mankind, they must be prepared to cross traditional curricular and subject matter boundaries. We can look forward to finding this reflected in present and future committee programs.

LEWIS K. DOWNING

The nominating committee of the Civil Engineering Division presents the following for the year 1960–1961:

Chairman (1960–61): F. Burt Farquharson, University of Washington, Seattle 5, Washington
Vice Chairman (1960–61): Emory E. Johnson, South Dakota State College, Brookings, South Dakota
Representative to Council (1960–62): Russell C. Brinker, Texas Western College, El Paso, Texas
Director (1960–63): Clarkson H. Oglesby, Stanford University, Stanford, California
Director (1960–63): Loren R. Heiple, University of Arkansas, Fayetteville, Arkansas

The above nominations will leave the following officers of the division already elected and serving as follows:

Secretary (1959–61): G. Reed Shaw, also serving as editor of the division
Director (1959–61): William S. LaLonde, Jr.
Director (1959–61): Paul F. Keim
Director (1959–62): Milton E. Bender
Director (1959–62): Harmer A. Weeden

The By-Laws of the Division provide that additional nominations may be made by petition signed by ten members in good standing and directed to the Chairman within thirty days of this published announcement. If more than one nomination is made for any office it will be the duty of the Secretary to prepare and send mail ballots to all members of the Civil Engineering Division.

G. REED SHAW
Secretary-Editor

What's Going on in ASEE

W. LEIGHTON COLLINS, *Secretary*

Membership was one of the important items discussed at the November meetings of the General Council and Executive Board. An additional 50 individual members were approved, but the 250 for the year is not as good as the progress made the past few years. Forty-four per cent of those joining were under 36 years of age, 28% came from non-member institutions, and 18% came from non-educational institutions. Only 65 of the 153 active member institutions had one or more new members in five months! Industrial and affiliate memberships are increasing gradually, but here as well as for individual memberships everyone must assume some responsibility for growth. Twenty-five requests for life membership were approved.

The additions and changes (and some corrections) for the 1960 Yearbook-Directory totaled about 3000 in the alphabetical (one third of the membership), 2000 in the geographical, and 1600 in the occupational listings. The Editor reported that only about one out of every seven papers was being published, despite using smaller type in the JOURNAL. Did you notice the difference? About 10% more material can be published on the same number of pages. Present indications are that the aimed-for increase in advertising of 10% will be reached.

The receipt of the gift of a Thermo-Fax copying machine and a supply of paper from the Minnesota Mining and Manufacturing Company was announced. It seems that the Treasurer's eagle eye recognized the need as critical and saw that something was done about it.

The printing of newly developed Society publications such as "Recruiting Practices and Procedures—1959" or reprinting old ones such as "Evaluation of Engineering Education" always presents budgetary problems. To overcome the difficulty, the Executive Board authorized the establishment of a revolving fund for publications, the fund to be developed from the sale of publications.

Another item pertaining to publications was the decision to accept "teaching ads" from "reputable schools" outside the U. S. and Canada. It is unfortunate that more schools don't use this facility; if they did, it would be easier on the Secretary—he wouldn't have to answer so many letters asking for names or asking for jobs.

Finances

The Treasurer's report indicated that the financial situation at the end of the first quarter was good. The short-term investment procedure in Treasury Notes was being refined, and will increase interest income considerably. A study of institutional dues and costs of direct services rendered was authorized.

Both ECAC and ECRC reported that their organizational structure and functioning were being studied, in accordance with the general instructions given to the Planning Committee last June. ECRC also reported that its biennial "Research Review" was available and that copies could be obtained from ASEE headquarters for only $2.00 per copy, a real bargain! The General Council, on ECRC's recommendatoin, voted that ASEE write to the American Council on Education, the presidents of member institutions, the American Association of Universities, etc. regarding the necessity to modify legislation to permit the National Institute of Health to accept the principles of Circular A-21 of the Bureau of the Budget and the overhead provisions contained therein.

Summer Schools

Favorable actions were taken on the following summer schools:

1960—Electrical Engineering Division —International Conference on Electrical Engineering Education, with Syracuse University.
1960—Industrial Engineering Division —Metal Processing, with the ASTE at Purdue.
1961—Electrical Engineering Division —National Conference on Systems Engineering, with the University of Pennsylvania.

Because of the continued high interest in aid to engineering education in foreign countries, the International Relations Committee was instructed to take a hard look at the whole problem, to confer with necessary governmental agencies and other groups, and to report in the spring what the Society legitimately and profitably can do. Vice President Easton and Secretary Collins also were instructed to proceed with a proposal for establishing a foreign visitors program, coordinating efforts with EJC's current project. Secretary Collins was designated as ASEE's official representative to the Pan American Congress on Engineering Education. A joint proposal of EJC, ECPD, and ASEE for an eight man delegation has been submitted to the National Science Foundation.

The Nuclear Committee announced the joint sponsorship with AEC of the following eight-week summer institutes:

1. *Intermediate Reactor Physics*, North Carolina State.
2. *Radiation Effects, Theory and Experiment*, University of Michigan.
3. *Effects of Nuclear Radiation (Radiation Damage)*, Cornell.
4. *Special Nuclear Studies*, Argonne National Laboratory.
5. *Basic or Beginning*, Purdue University and North Carolina State.
6. *Technical Institute Teachers*, Pennsylvania State University.

The American Nuclear Society was approved as a co-sponsor of the "Objective Criteria Study of Nuclear Education."

Publication of the final report of the Technical Institute Survey Committee in book form as *The Technical Institute in America*, as a unit in the Carnegie Series in American Education, published by the McGraw-Hill Book Company, Inc. was approved. At the request of the Engineering Economy Division the publication of "The Engineering Economist" as an official publication of the Society was approved. The difference between ASEE's "Recruiting Practices and Procedures—1959" and the publication of the College Placement Council—U. S. Chamber of Commerce "code" resulted in the unanimous adoption of a resolution recommending to deans of engineering and placement officers dealing with engineering students that they insist on the use of ASEE's "code." The specific reason is that the CPC–USCC document "leaves to the discretion of the employer the interpretation of the significance of some factors which may be vital to the student's future professional development in an engineering career."

The revision of the charter of ECPD, enabling it to be granted a C-3 tax exempt status, was approved. This is one of the steps necessary to amalgamate ECPD and EJC.

The problem of the construction industry and the American Institute of Architects in the mounting shortage of engineers interested in illumination, heating and air-conditioning, and, to a lesser extent, structures, was discussed by the Executive Board. It was voted that ASEE wished to be kept informed of developments and have an observer at future meetings, but would not, at the present time, endorse any proposals for joint actions.

The Executive Board also advised the Secretary to explore with Smith, Sternau, and Son that firm's suggestion that ASEE be interested in group life insurance. In the General Council meeting the question of continued education for engineers was raised, and it was suggested that ideas should be transmitted to the Society Secretary.

The Annual Meeting at Purdue, June 20 to 24, and the splendid programs being planned for it, were frequently referred to. Make your plans to be there!